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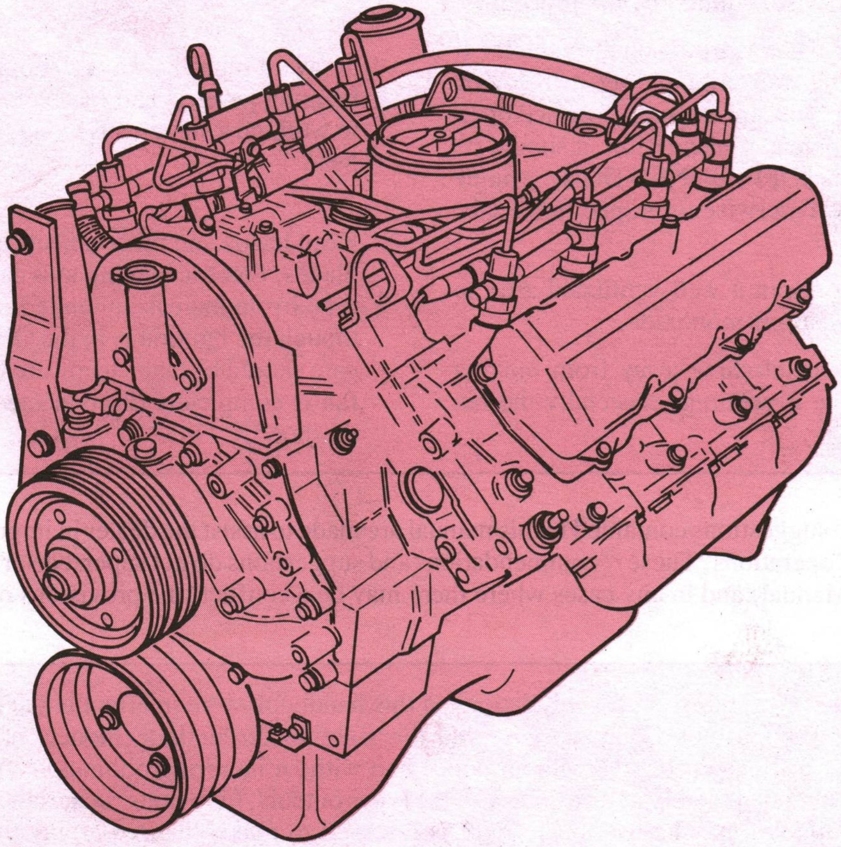
6.9L Diesel Engine



Ford Parts and Service Division
Training and Publications Department

IMPORTANT SAFETY NOTICE

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all motor vehicles, as well as for the personal safety of the individual doing the work. This manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools, and parts for servicing vehicles, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from the instructions provided in this manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools or parts.

As you read through the procedures, you will come across NOTES, CAUTIONS, AND WARNINGS. Each one is there for a specific purpose. NOTES give you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the vehicle. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on a vehicle.

- Always wear safety glasses for eye protection.
- Use safety stands whenever a procedure requires you to be under the vehicle.
- Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake when working on the vehicle. If you have an automatic transmission, set it in PARK unless instructed otherwise for a specific service operation. If you have a manual transmission, it should be in REVERSE (engine OFF) or NEUTRAL (engine ON) unless instructed otherwise for a specific service operation.
- Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide.
- Keep yourself and your clothing away from moving parts when the engine is running, especially the fan and belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, catalytic converter and muffler.
- Do not smoke while working on the vehicle.
- To avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle. Tie long hair securely behind the head.
- Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.

The recommendations and suggestions contained in this manual are made to assist the dealer in improving his dealership parts and/or service department operations. These recommendations and suggestions do not supersede or override the provisions of the Warranty and Policy Manual, and in any cases where there may be a conflict, the provisions of the Warranty and Policy Manual shall govern.

The descriptions, testing procedures, and specifications in this handbook were in effect at the time the handbook was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications, design or testing procedures without notice and without incurring obligation. Any reference to brand names in this manual is intended merely as an example of the types of tools, lubricants, materials, etc. recommended for use. Equivalents, if available, may be used. The right is reserved to make changes at any time without notice.

6.9L DIESEL REFERENCE MANUAL

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INTRODUCTION
ABOUT THIS BOOKLET

In a continuing effort to improve economy and performance, Ford is introducing a new 6.9L diesel engine for the E-Series and F-Series trucks. This engine is offered as an option on the F-350, E-350, and on the F-250 and E-250 heavy-duty.

This book is divided into five sections. The basic description of the sections is as follows:

I 6.9L Diesel engine
  a. Description of engine
  b. Description of components
II Fuel system
  a. Description of fuel system
  b. Operation and maintenance
  c. Diagnosis — Fuel system
  d. Diagnosis — Injection nozzles
III Electrical (Glow Plug) system
  a. Description
  b. Operation and maintenance
  c. Diagnosis — Glow plug system
IV Engine system components (other than fuel and glow plugs)
  a. Description
V Special service tools

OBJECTIVES

The objectives of this manual are to provide the service technician with a description of the:

- 6.9L diesel engine
- Components
- Fuel system
- Electrical (glow plug) system
- Special service tools (to explain how they work)
- Diagnosis procedures

GENERAL DESCRIPTION — 6.9L DIESEL ENGINE

The 6.9L diesel engine (Figures 1 & 2) is a four-cycle naturally-aspirated V-8 with overhead valves. It has a displacement of 6.9 liters (420 cubic inches).

When viewing the engine from the front, (Figures 1 & 2), the left bank of cylinders is numbered 1, 3, 5 and 7 with number 1 being at the front. The firing order is 1-2-7-3-4-5-6-8. The crankcase has been especially designed to withstand the loads of diesel operation. It utilizes a four bolt main bearing and five main bearing unit, with fore and aft thrust controlled at the center (No. 3) bearing to assure a rigid, inflexible support for the rotating parts. The crankcase also has piston oil cooling jets, which direct oil to the underside of the piston.

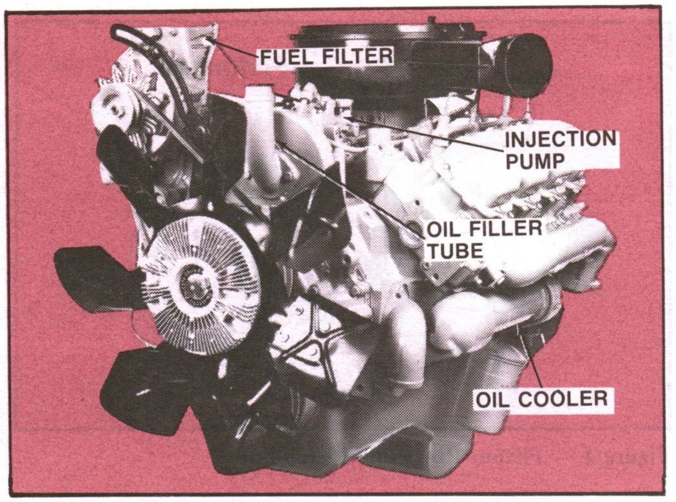


Figure 1 — 6.9L 3/4 Left View Diesel Engine

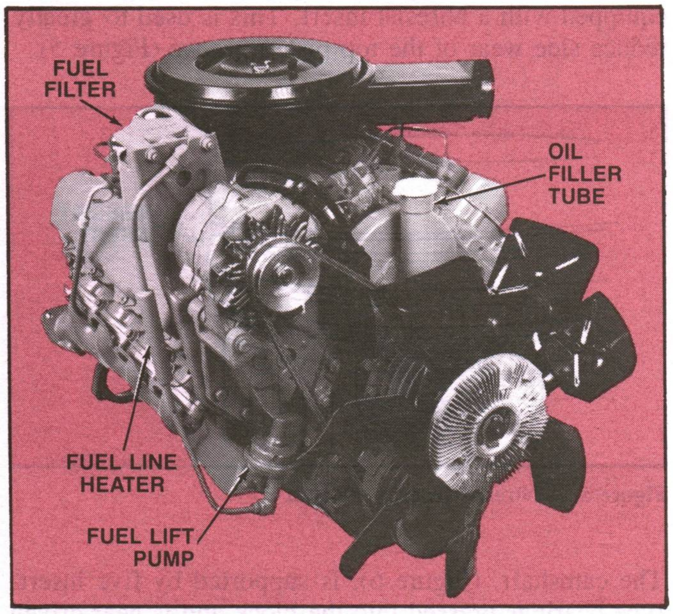


Figure 2 — 3/4 Right Side View — 6.9L Diesel Engine

Heavy-duty forged steel connecting rods (Figure 3) are attached to the crankshaft, two to each bearing throw. A free-floating type piston pin is used (Figure 4) which permits the pin to move or float freely in piston and rod. The pin is held in place with pin retaining rings.

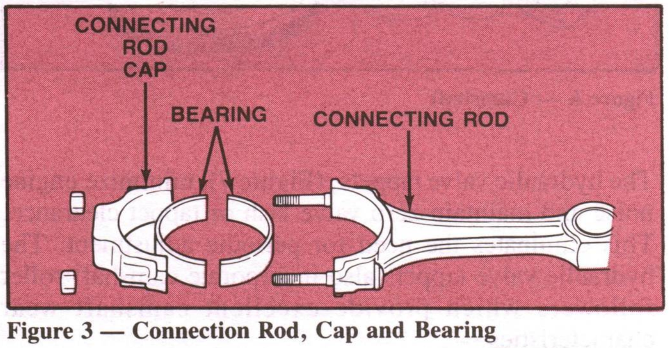


Figure 3 — Connection Rod, Cap and Bearing

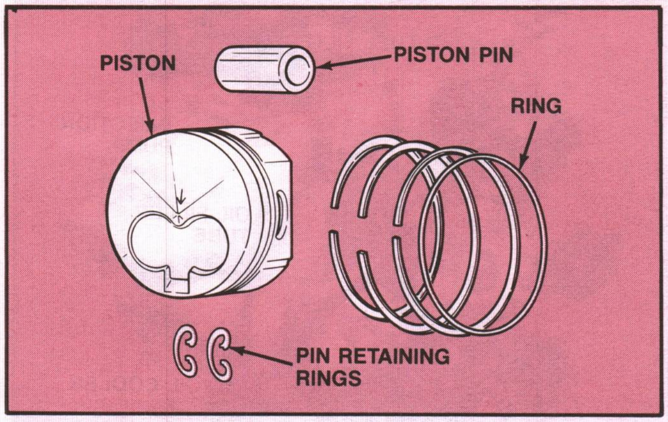


Figure 4 — Piston, Rings and Piston Pin

The aluminum-alloy pistons are fitted with compression rings and an oil ring. The top piston ring groove is equipped with a Niresist insert. This is used to greatly reduce side wear of the top piston groove (Figure 5).

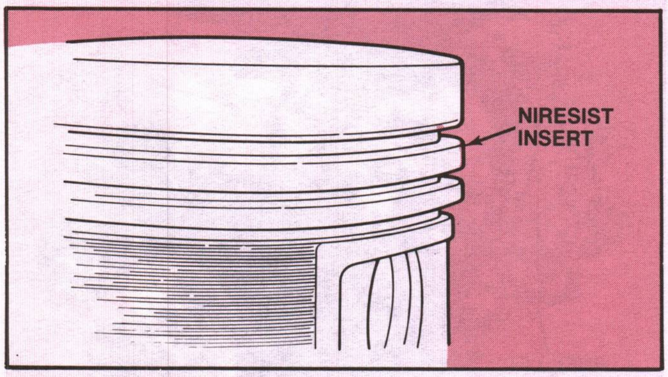


Figure 5 — Niresist Insert — Piston

The camshaft, (Figure 6), is supported by five insert-type bearings pressed into the block and is gear driven from the crankshaft. The end thrust of the camshaft is controlled by a thrust flange, located between the front camshaft journal and the camshaft drive gear.

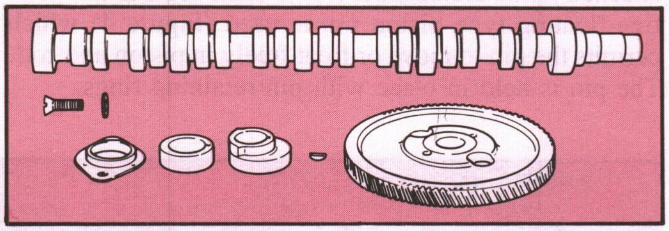


Figure 6 — Camshaft

The hydraulic valve tappets, (Figure 7), minimize engine noise and maintain zero valve lash or tappet clearance. This eliminates the need for periodic adjustment. The hydraulic valve tappets also incorporate camshaft roller followers which provide excellent camshaft wear characteristics.

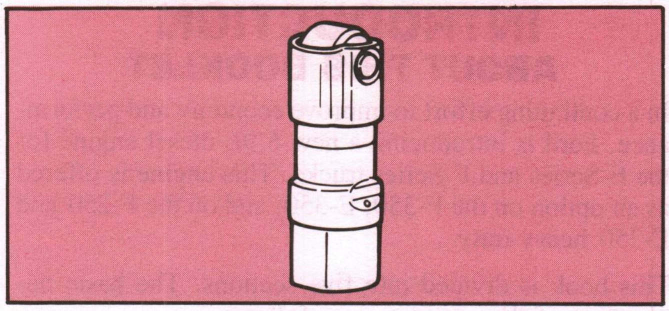


Figure 7 — Hydraulic Valve Tappet

The cylinder head assemblies feature pre-combustion chambers, (Figure 8), which provide superior combustion characteristics to produce very high volumetric and thermal efficiencies. The cylinder heads used on the engine are equipped with a positive valve rotating mechanism on both the intake and exhaust valves. This device is called roto-coil and is located at the base of each valve (Figure 9).

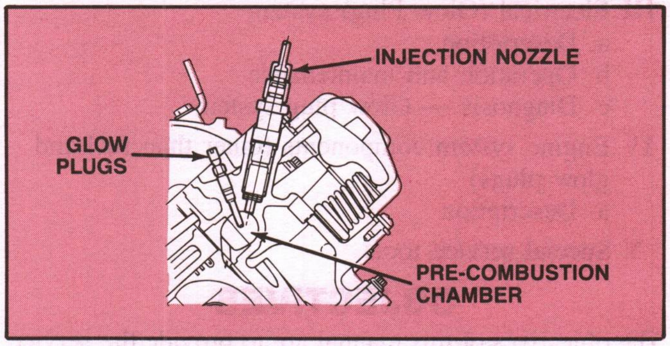


Figure 8 — Combustion Chamber Configuration

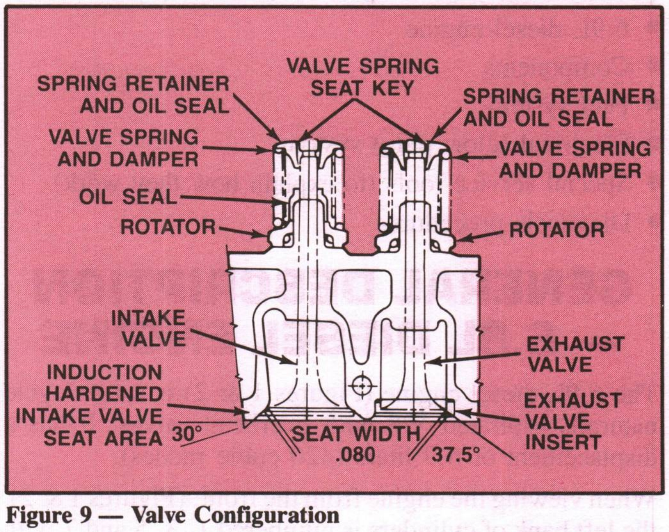


Figure 9 — Valve Configuration

The engine is equipped with a fully closed positive crankcase ventilation system. The ventilation system is controlled by a crankcase depression regulator (CDR) mounted on the rear of the intake manifold (Figure 10). The crankcase depression regulator draws vapors from the top of the valley pan into the intake manifold. It is a diaphragm type pressure differential regulator whose purpose is to maintain very close to atmospheric pressure in the crankcase.

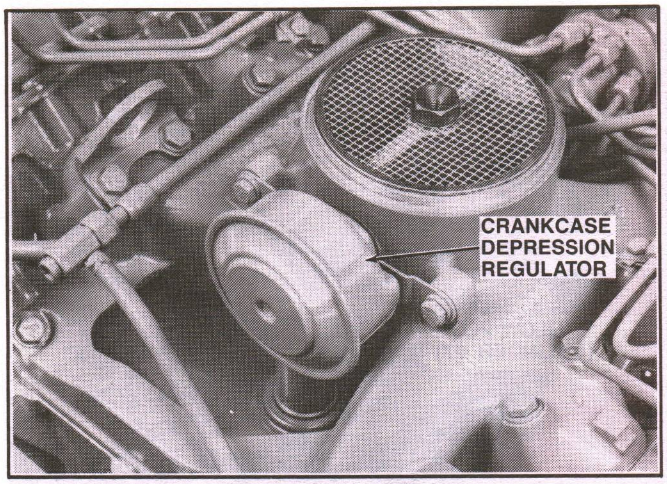


Figure 10 — Crankcase Depression Regulator (CDR)

The rotary-type injection pump (Figure 11) is located between the cylinder heads and intake manifold at the top of the engine. The engine governor is integral with the fuel injection pump.

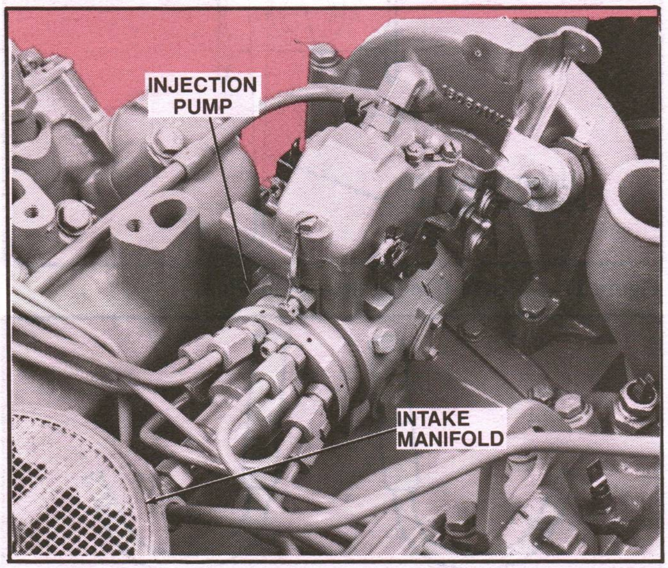


Figure 11 — Injection Pump

ENGINE SYSTEM COMPONENTS

The basic parts and components of the diesel engine are similar in location and function to those of the gasoline engine. There are some components that are unique to the diesel, and others unique only to the 6.9L diesel engine.

The components (unique to the 6.9L diesel), location and function are as follows.

Injection Pump

The injection pump is located on the top front of the engine (Figures 11 & 12). Its function is to deliver fuel (received from the fuel pump) at a high pressure through the injection lines to the injection nozzles at timed intervals.

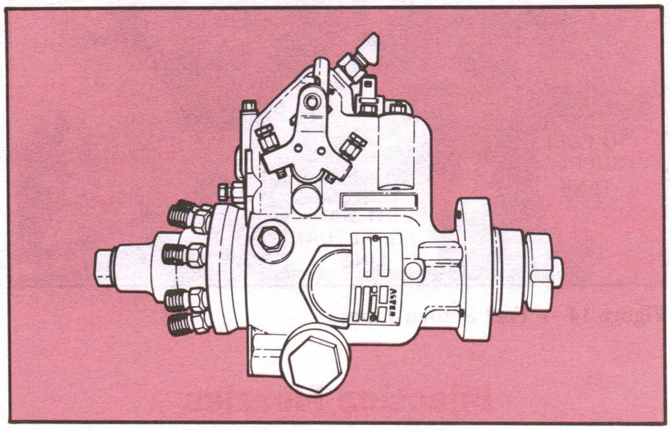


Figure 12 — Injection Pump

Injection Lines

The injection lines are located on the top of the engine (Figure 13). The lines connect the fuel injection pump to the injection nozzles through which the fuel is delivered.

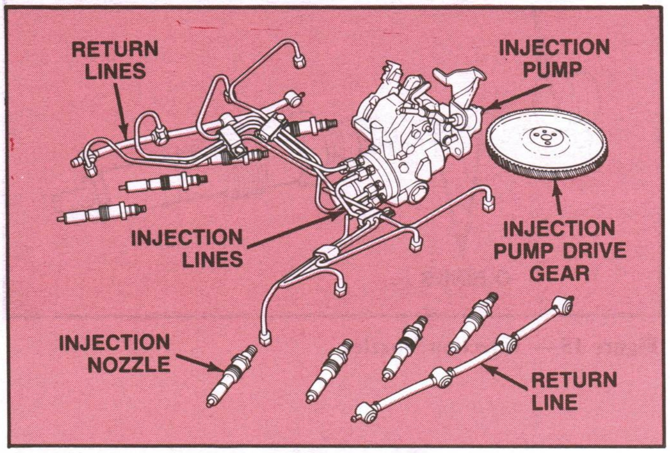


Figure 13 — Injection Lines

CAUTION: Under no circumstances are the injection lines to be bent or crimped. Doing so could impede the flow of fuel to the injection nozzles, which could cause the engine to run rough.

Fuel Return Lines

The fuel return lines are located on the fuel filter, injection pump and on each injection nozzle (Figure 14). Their function is to return unused fuel to the fuel tank.

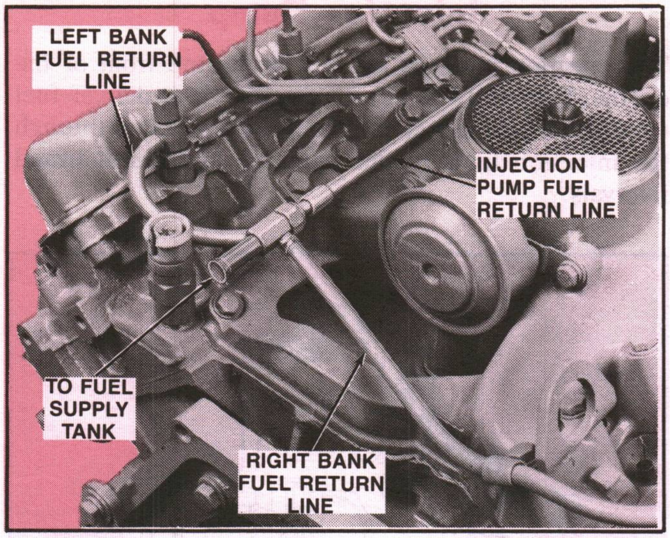

LEFT BANK FUEL RETURN LINE
INJECTION PUMP FUEL RETURN LINE
TO FUEL SUPPLY TANK
RIGHT BANK FUEL RETURN LINE

Figure 14 — Fuel Return Lines

Injection Nozzles

The injection nozzles are located in the top of the cylinder heads, one per cylinder (Figures 8 & 15). Their function is to direct a metered amount of fuel, under high pressure from the fuel injection pump, into the engine combustion chamber.

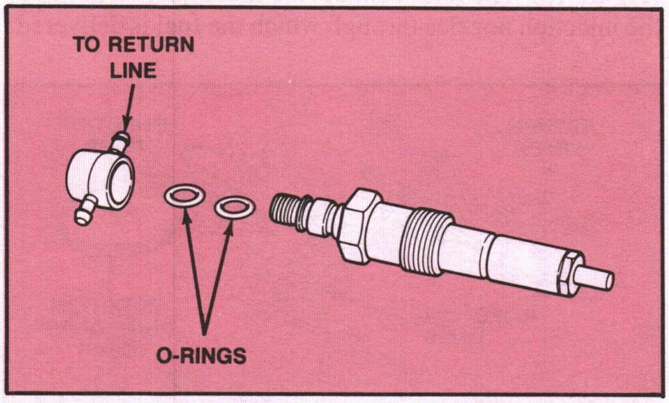


Figure 15 — Injection Nozzles

Glow Plugs

The glow plugs are located in the top of the cylinder heads, one per cylinder (Figures 8 & 16). Their function is to help in the ignition of the fuel when the engine is first started, by pre-heating the air inside the combustion chamber.

Piston Cooling Tubes

The piston cooling tubes are located inside the cylinder block, one per cylinder (Figures 17 and 18). Their function is to direct a stream of oil to the underside of the piston to help in the cooling of the piston.

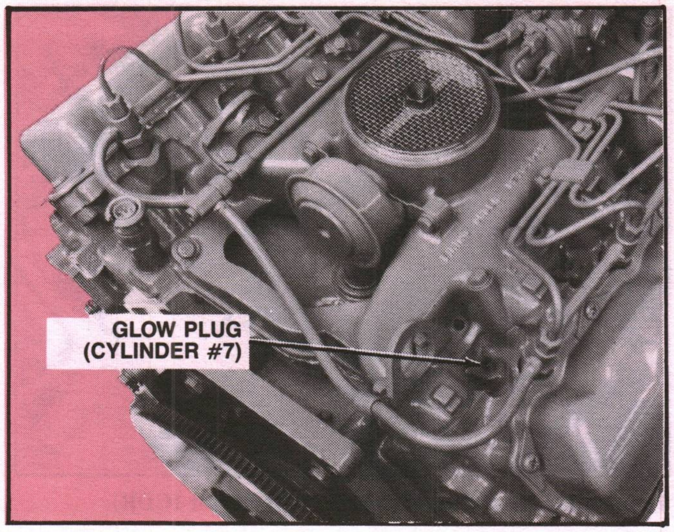


Figure 16 — Electrical Glow Plug

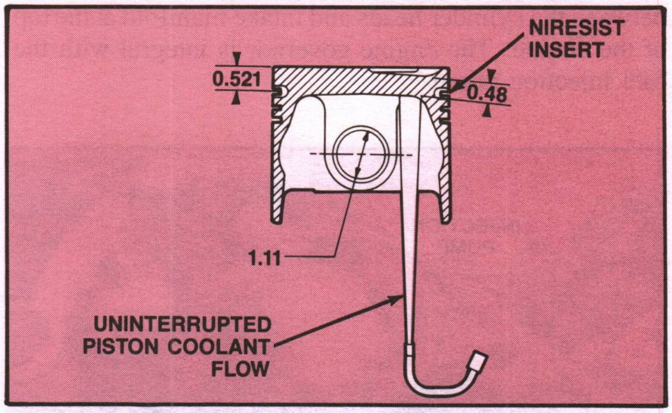


Figure 17 — Piston Cooling Jet — Oil Flow

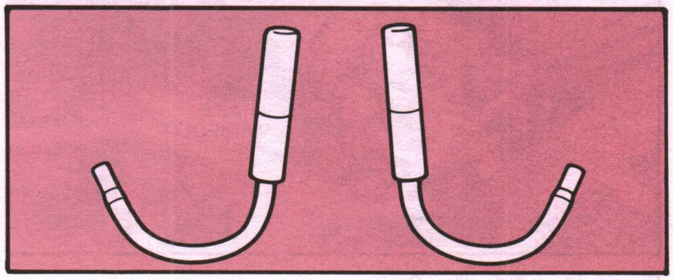


Figure 18 — Piston Oil Cooling Jets

Oil Cooler and Filter

The oil cooler and filter are located on the left side of the cylinder block (Figure 19). The oil cooler's function is to help in the dissipation of heat from the engine oil. The oil flows around the cooler's tubes while the engine coolant flows through the inside of the tubes dissipating the heat from the oil.

Fuel Filter

The fuel filter is located on a bracket on the top front of the engine (Figure 20). It's a screw-on design (similar to an oil filter) and is used to allow only clean fuel into the fuel injection pump.

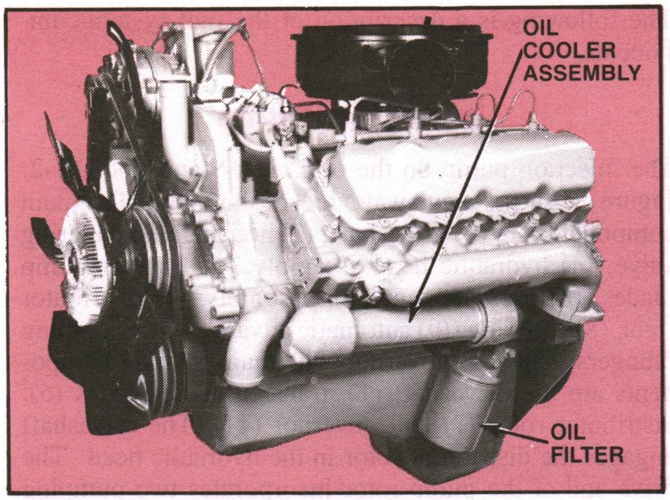


Figure 19 — Oil Cooler and Filter

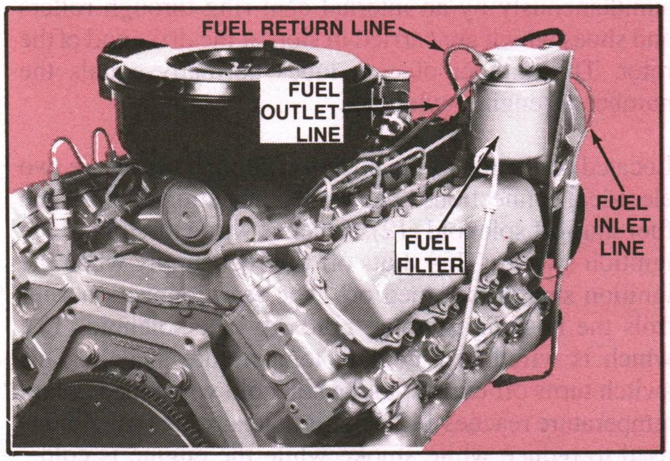


Figure 20 — Fuel Filter

Water/Fuel Separator

The water/fuel separator for the F-Series is located inside the engine compartment on the left hand side (Figure 21). On the E-Series the separator is located under the rear of the engine at the left hand frame rail (Figure 22). With the E-Series there is also a remote water drain release located on the left cowl top inside the engine compartment. The purpose of the water/fuel separator is to remove water from the fuel before it enters the fuel filter. The separator needs to be drained periodically or when the "Water in Fuel" lamp stays on with the engine running.

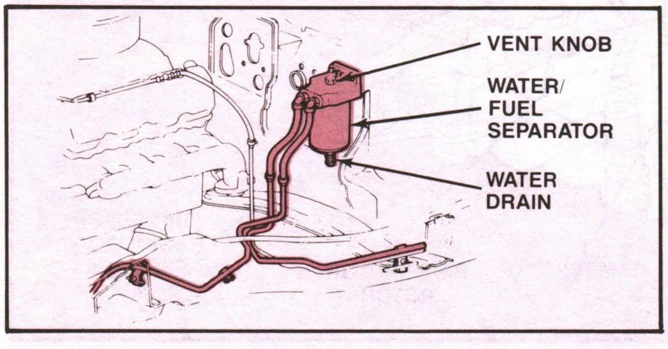


Figure 21 — Water/Fuel Separator — F-Series

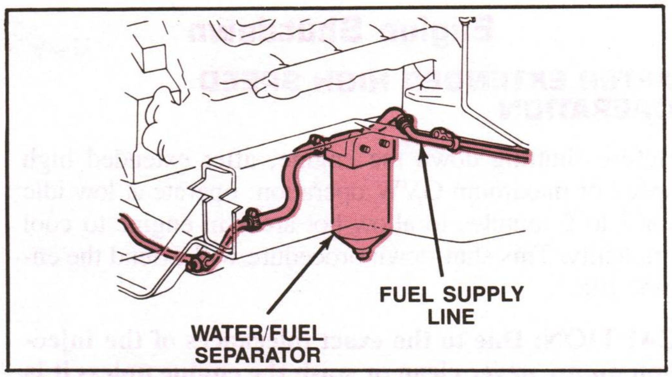


Figure 22 — Water/Fuel Separator — E-Series

ENGINE OPERATING CONDITIONS

Start-up

The start-up procedure for the 6.9L diesel engine is similar to a gasoline engine. The 6.9L diesel uses an electrical glow plug system to pre-heat the combustion air in the pre-chamber. A wait of up to 10 seconds is required at certain times, prior to the starting of the engine. A wait lamp in the instrument cluster goes on when the ignition key is turned to the "On" position. It goes off within 4-10 seconds depending on the temperature of the engine coolant (the lower the temperature of the engine coolant, the longer the wait lamp stays on). The glow plugs may function on and off depending on the coolant temperature, after the engine is started, but the wait lamp will stay off once the engine has started.

The 6.9L vehicles are equipped with a water temperature warning lamp and a water temperature gauge. If the water temperature warning lamp lights, the engine should be stopped even if the gauge does not show an overheating problem.

OPERATING PRECAUTIONS AND RECOMMENDATIONS

Checks during operation:

- Observe general performance of engine while running.
- Listen for unusual noises.
- Make frequent checks of instruments.

Low idle speed for the 6.9L engine is 675 ± 25 RPM (manual transmission in neutral, automatic transmission in gear). If engine operation includes extended periods of idling, low idle speed should be temporarily increased by adjusting the idle speed to 1200 RPM during these periods.

NOTE: Return engine to specified low idle speed before normal operation is resumed.

Engine Shutdown

AFTER EXTENDED HIGH SPEED OPERATION

Before shutting down the engine, after extended high speed or maximum GVW operation, operate at low idle for 3 to 5 minutes to allow hot areas in engine to cool gradually. This shut-down procedure will extend the engine life.

CAUTION: Due to the exact tolerances of the injection pump, never clean or wash the engine unless it is cold. Failure to do so could result in damage to the injection pump.

For more detailed information regarding engine operation during cold and warm temperatures, refer to the Operator's Manual supplied with the vehicle.

FUEL SYSTEM DESCRIPTION

The components of the fuel system are as follows:

- Fuel supply and return lines
- Motorized fuel selector valve
- Water/fuel separator
- Fuel pump
- Injection pump
- Injection lines
- Injection nozzles

The following is a description of the fuel system components.

Injection Pump

The injection pump on the 6.9L is a Stanadyne DB-2. Figure 23 shows a cutaway view of the pump. The main components are (1) driveshaft, (2) housing, (3) metering valve, (4) hydraulic head assembly, (5) transfer pump blades, (6) pressure regulator assembly, (7) distributor rotor, (8) cam ring, (9) automatic advance, (10) pumping plungers, and (11) governor. The main rotating components are the driveshaft (1), transfer pump blades (5), distributor rotor (7) and governor (11). The driveshaft engages the distributor rotor in the hydraulic head. The drive end of the pump rotor incorporates two pumping plungers. The plungers are actuated toward each other simultaneously by an internal cam ring through rollers and shoes which are carried in slots at the drive end of the rotor. The number of cam lobes normally equals the number of engine cylinders.

Located on the top of the injection pump housing are two electrical connections. The front connection controls the fuel shut-off solenoid (12), which is wired directly to the ignition switch. This shuts off the fuel supply when the ignition switch is turned off. The rear connection controls the housing pressure cold advance solenoid (13), which is wired to a coolant temperature switch. This switch turns off current to the solenoid when the coolant temperature reaches 112°F. This cold advance solenoid is used to reduce white smoke while the engine is cold.

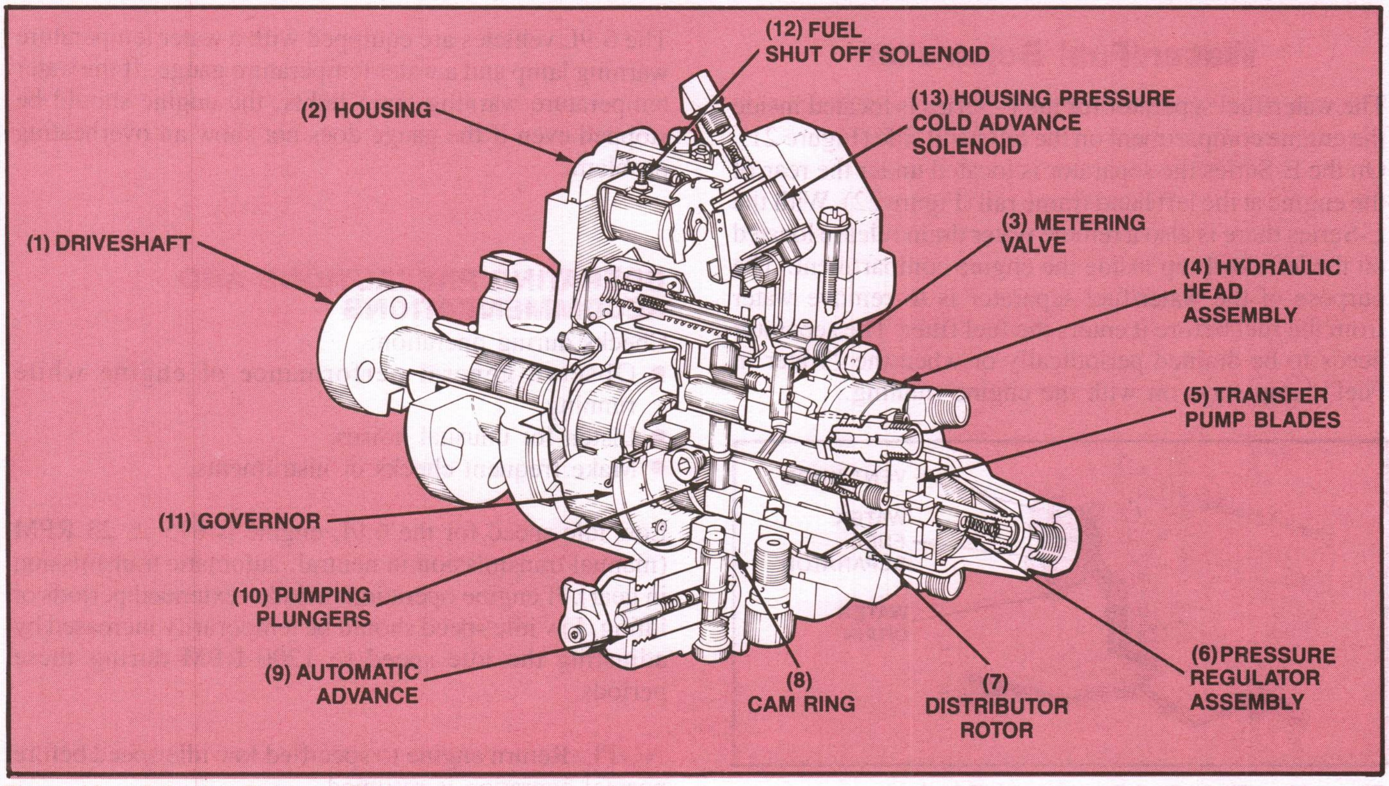


Figure 23 — Injection Pump — Cutaway

Figure 24 shows a cutaway view of the pump showing the fuel flow. The operating principles of the pump can be understood more readily by following the fuel circuit during a complete pump cycle. Fuel flows into the pump inlet through the inlet filter screen (1) by the vane type fuel transfer pump (2). Some fuel is bypassed through the pressure regulator assembly (3) to the suction side. Fuel under transfer pump pressure flows through the center of the transfer pump rotor, past the transfer pump pressure port and the rotor retainers (4) into a circular groove on the rotor. It then flows through a connecting passage (5) in the head to the automatic advance (6) and up through a radial passage (8) to the metering valve. The radial position of the metering valve, controlled by the governor, regulates flow of the fuel into the radial charging passage (9), which incorporates the head charging ports. As the rotor revolves, the two rotor inlet passages (10) register with the charging ports in the hydraulic head, allowing fuel to flow into the pumping chamber. With further rotation, the inlet passages move out of registry and the discharge port of the rotor registers with one of the head outlets. While the discharge port is opened, the rollers (11) contact the cam lobes forcing the plungers together. Fuel trapped between the plungers is then pressurized and delivered by the nozzle to the combustion chamber.

Self-lubrication of the pump is a built-in feature of the design for this injection pump. As fuel at transfer pump pressure reaches the charging ports, slots on the rotor shank allow fuel and any entrapped air to flow into the pump housing cavity. In addition, an air vent passage in the hydraulic head connects the outlet side of the transfer pump with the pump housing. This allows air and some fuel to be bled back to the fuel tank via the return line. The bypassed fuel fills the housing, lubricates the internal components, and cools and carries off any small air bubbles. The pump operates with the housing completely full of fuel. There are no dead air spaces within the pump.

NOTE: Special equipment and facilities are required for injection pump rebuilding. Check the warranty status as to whether the injection pump is to be replaced or rebuilt at an authorized rebuilder. Refer to the Engine/Emissions Diagnosis Manual for authorized minor repairs.

Injection Nozzles

The injection nozzles have an inward opening, differential hydraulically-operated, spray hole. Their function is to direct a metered amount of fuel, under high pressure from the fuel injection pump, into the engine combustion chamber.

The injection nozzle assembly consists of two principal sub-assemblies, the nozzle and the nozzle holder.

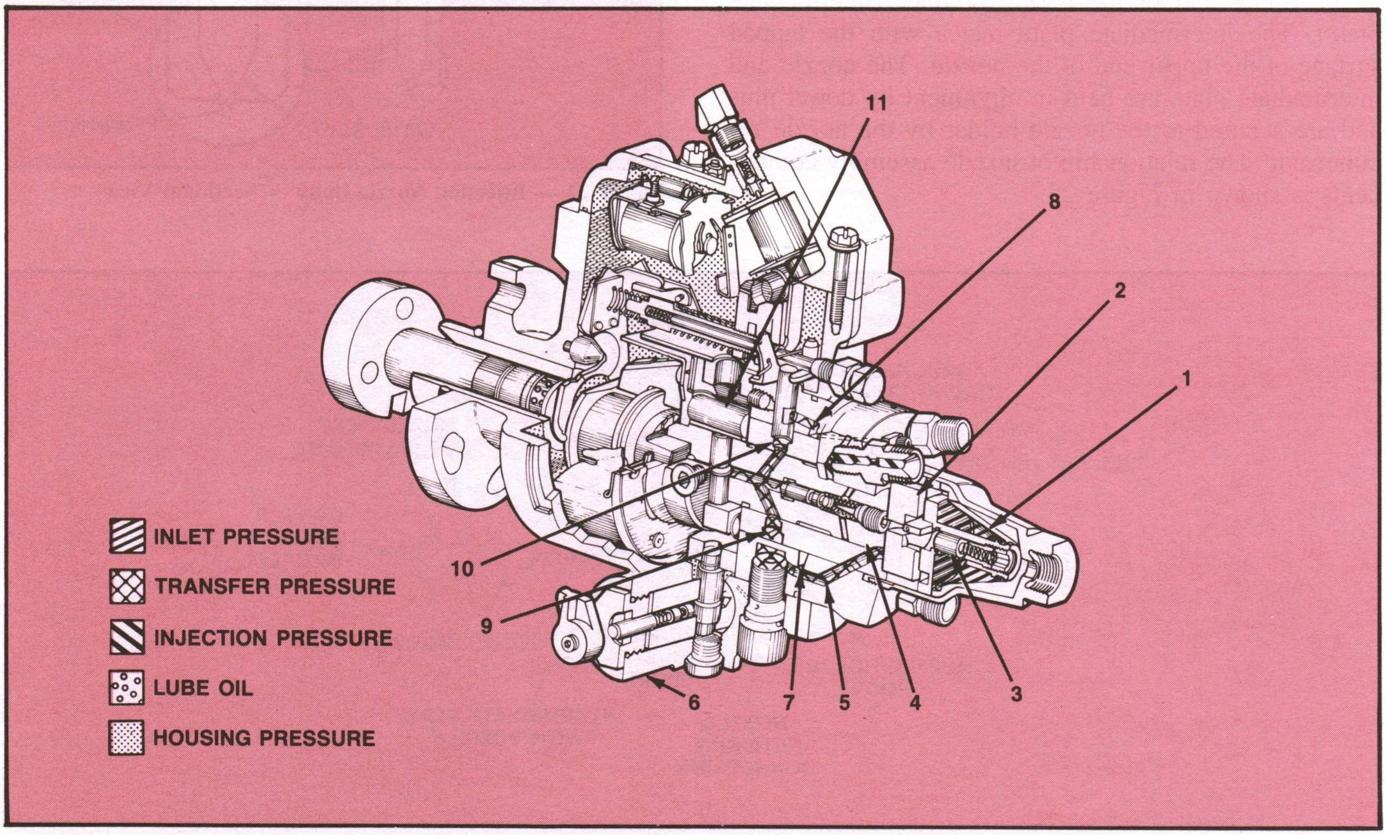


Figure 24 — Injection Pump — Fuel Flow

Figure 25 illustrates a sectional view of the injection nozzle assembly. Figure 26 illustrates an exploded view of the injection nozzle assembly.

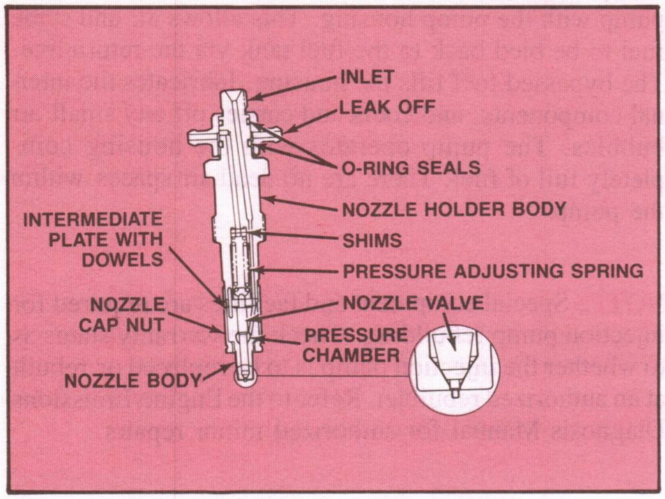


Figure 25 — Injection Nozzle — Sectional View

The nozzle holder is used to hold the nozzle in its correct position in the cylinder head and to provide channels for conducting fuel oil to the nozzle. The holder also contains the spring retainer (intermediate plate) spring, and shims for adjusting the opening pressure of the nozzle valve. The lower end of the holder has an accurately ground and lapped surface which makes a leakproof and pressure tight seal with the corresponding lapped surface at the upper end of the spring retainer (intermediate plate). The intermediate plate mates with the lapped surface of the upper end of the nozzle. The nozzle and intermediate plate are held in alignment by dowel pins and are secured to the nozzle holder by the nozzle retainer nut. The relationship of nozzle assembly components is shown in Figure 25.

Figure 27 illustrates a sectional view of the nozzle body and nozzle valve. These parts are lapped to form an extremely close fitting, matched set. Body and valve cannot be exchanged singly and must be replaced as an assembly. The spray hole is sized to provide a spray pattern of finely atomized fuel to produce the most efficient combustion and engine performance. Operation of the injection nozzle assembly is simple and positive. The metered quantity of fuel from the injection pump enters the nozzle holder through the inlet fitting, and passes through connection ducts to the pressure chamber, just above the nozzle valve seat. At the instant the pressure of fuel acting on the differential area of the valve exceeds a predetermined spring load, it lifts the valve from its seat and fuel flows from the nozzle until delivery from the injection pump ceases. Then a positive cut-off of fuel occurs as the valve is seated by the nozzle spring. A certain amount of fuel seepage between lapped surfaces of the nozzle valve and body is necessary for lubrication. This leakage oil accumulates in the spring cavity and drains through to the leak-off provided for this purpose.

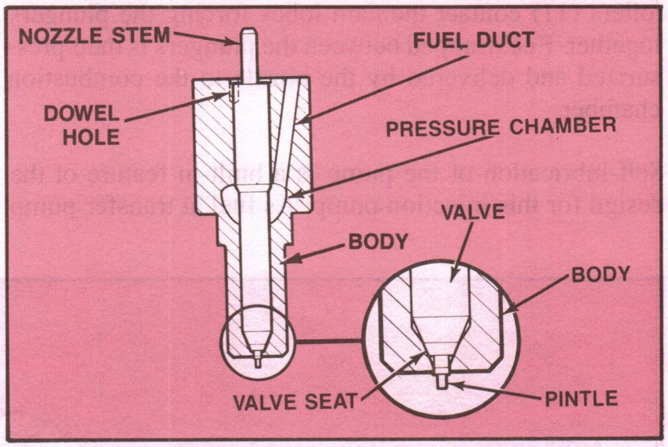


Figure 27 — Injection Nozzle Body — Sectional View

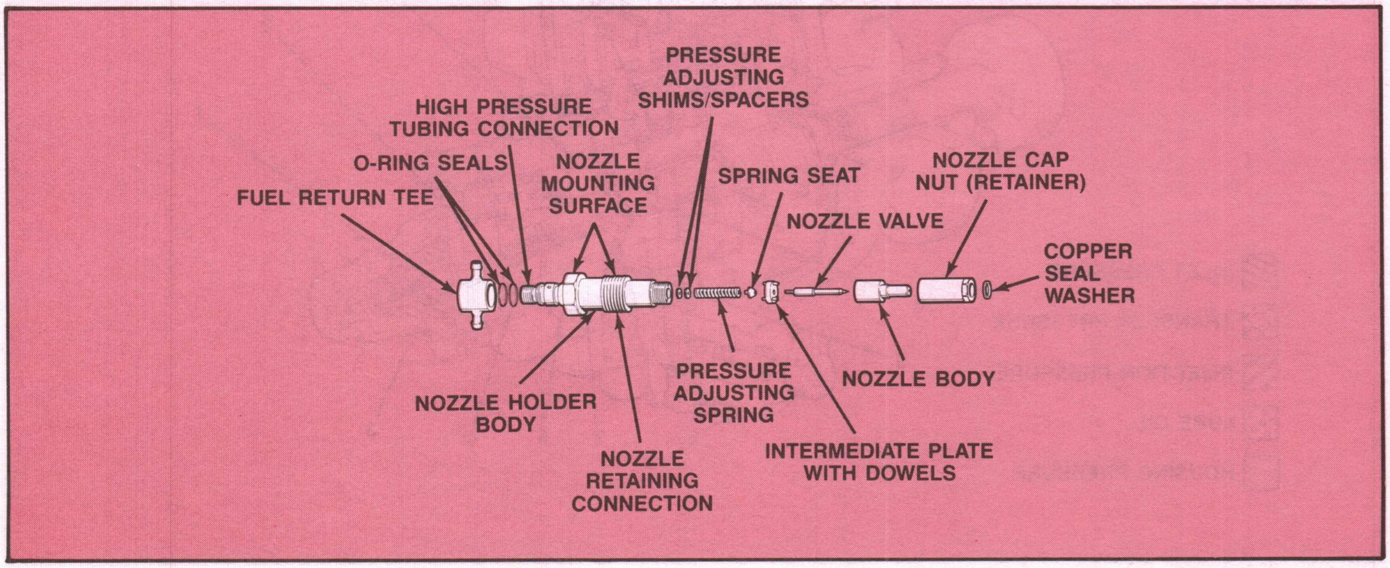

PRESSURE ADJUSTING SHIMS/SPACERS
HIGH PRESSURE TUBING CONNECTION
O-RING SEALS
NOZZLE MOUNTING SURFACE
SPRING SEAT
NOZZLE CAP NUT (RETAINER)
FUEL RETURN TEE
NOZZLE VALVE
COPPER SEAL WASHER
NOZZLE HOLDER BODY
PRESSURE ADJUSTING SPRING
NOZZLE BODY
NOZZLE RETAINING CONNECTION
INTERMEDIATE PLATE WITH DOWELS

Figure 26 — Injection Nozzle — Exploded View

NOTE: Special equipment and facilities are required for the rebuilding of injection nozzles. Check warranty status as to whether the injection nozzles are to be replaced or rebuilt at an authorized rebuilder.

Fuel Pump

The fuel pump is similar to the type used on gasoline engines. It is operated by a lever that runs on the fuel pump eccentric located on the camshaft.

Injection Lines

The injection lines (Figure 28), are precisely cut and bent to specification so as to deliver a specified amount of fuel to the injection nozzles.

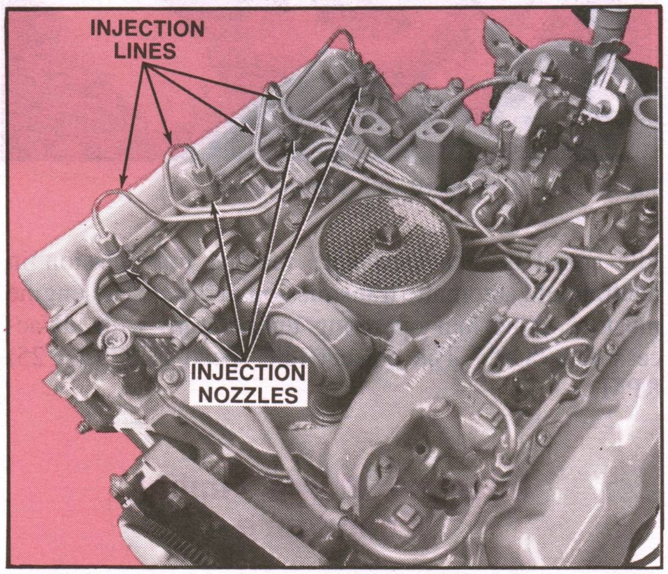


Figure 28 — Injection Lines

CAUTION: Under no circumstances are the injection lines to be bent or crimped. Doing so could impede the flow of fuel to the injection nozzles which could cause the engine to run rough.

Fuel Supply and Return Lines

Figure 29 shows a schematic of the fuel supply and return lines. The lift pump draws the fuel through the water/fuel separator from the supply tank. The fuel is then pumped through the fuel heater, and the fuel filter to the injection pump inlet. The injection pump then distributes the fuel to the injection nozzles.

Fuel is returned to the fuel tank by way of fuel return lines. A line runs off the fuel filter (fuel is metered through a .040″ [1.016mm] orifice) then connects to the right bank of injection nozzles. This line connects at the rear left of the engine to the fuel return lines from the injection pump and left bank of injection nozzles. Fuel is then returned to the fuel supply tank.

Water/Fuel Separator

The water/fuel separator (Figure 30) works on two principles: first, that water is heavier than diesel fuel and will sink to the bottom of the separator and second, that a "sock" attached to the inside of the separator at the fuel inlet will assist in the separation of water from the fuel. The water tends to cling to the inside of the sock, which in turn hangs down into the lower part of the separator.

If the separator becomes approximately 1/3 full with water, a warning indicator lamp will light on the instrument panel. Also, the lamp comes on when the ignition

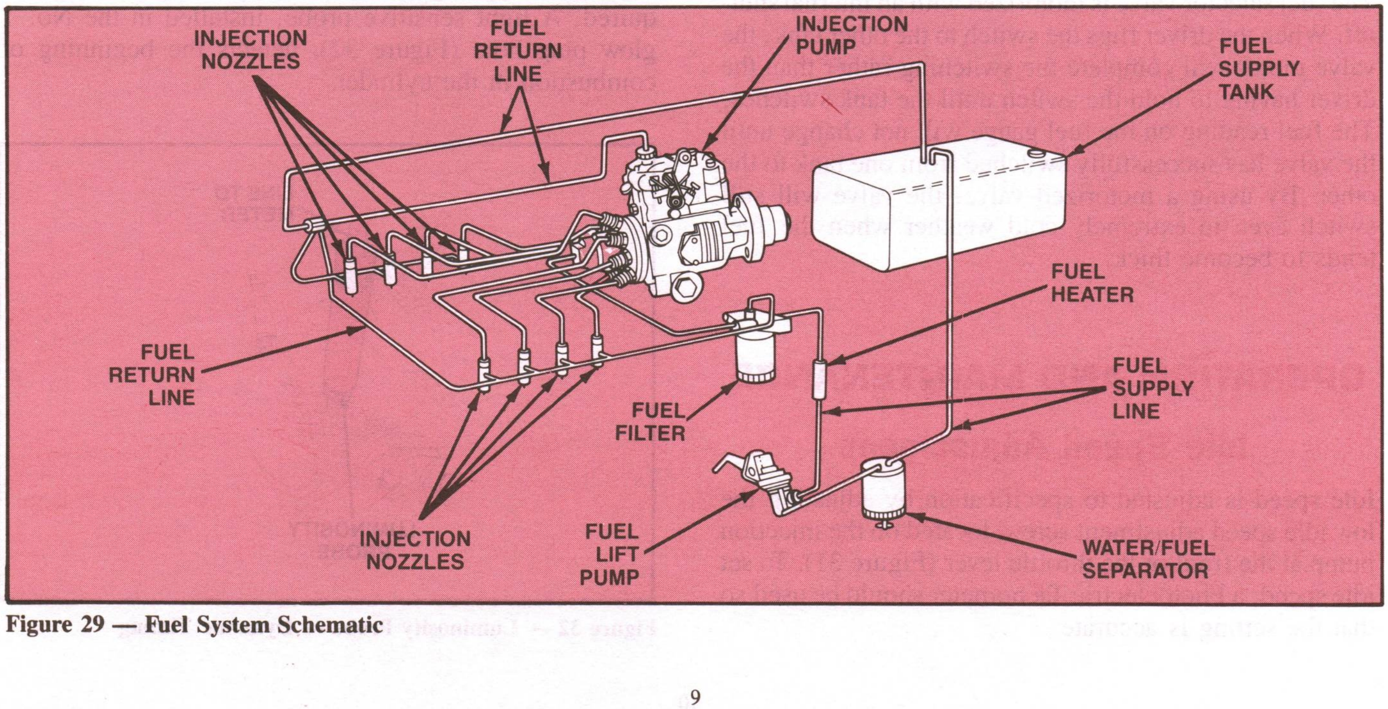


Figure 29 — Fuel System Schematic

key is switched to "START" to prove out the lamp and water level sensor circuit. Should the lamp stay "ON" after the engine is started, drain the water from the separator.

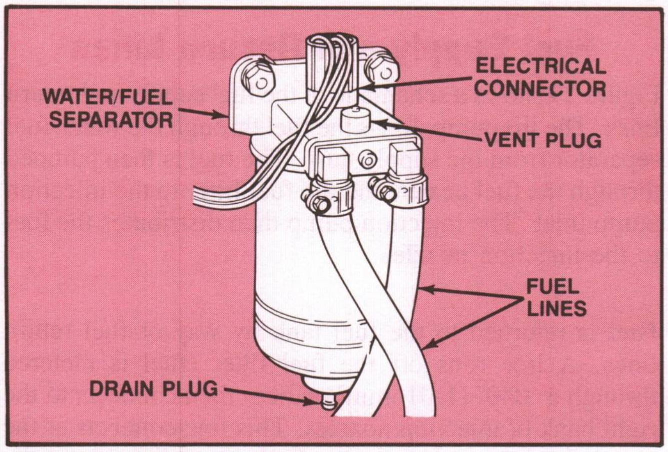


Figure 30 — Water/Fuel Separator

The F-Series water/fuel separator has a ball check valve that will automatically shut off the drain (when the bottom drain plug is opened), when the water has been drained from the separator. The check ball floats in water but will sink in diesel fuel.

The E-Series has no check ball and must be closed manually when the water has been drained off.

NOTE: F-Series production models of the 6.9L water/fuel separator will include a grated steel guard to protect the separator.

Motorized Fuel Selector Valve

The fuel selector valve is motorized with an internal shutoff. When the driver flips the switch to the other tank, the valve motor will complete the switching rather than the driver having to hold the switch until the tank switches. The fuel reading on the fuel gauge will not change until the valve has successfully switched from one tank to the other. By using a motorized valve, the valve will still switch even in extremely cold weather when the fuel tends to become thick.

OPERATION AND MAINTENANCE

Idle Speed Adjustment

Idle speed is adjusted to specification by adjusting the low idle speed adjustment screw, located on the injection pump at the front of the throttle lever (Figure 31). To set idle speed, a Photoelectric Tachometer should be used so that the setting is accurate.

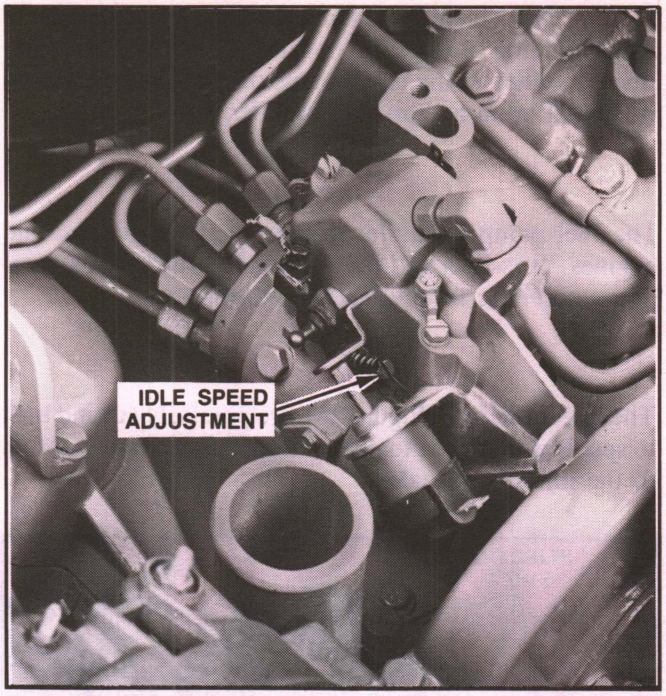


Figure 31 — Idle Speed Adjustment Screw

Idle speed is measured with manual transmission in neutral, and automatic transmission in drive. The engine must be at normal operating temperature with all accessories "Off." The correct idle speed is 675 (±25) RPM.

Injection Pump Timing Procedure

Dynamic injection timing is used to verify the timing of the injection pump. A luminosity timing meter is required. A light sensitive probe, installed in the No. 1 glow plug hole (Figure 32), detects the beginning of combustion in the cylinder.

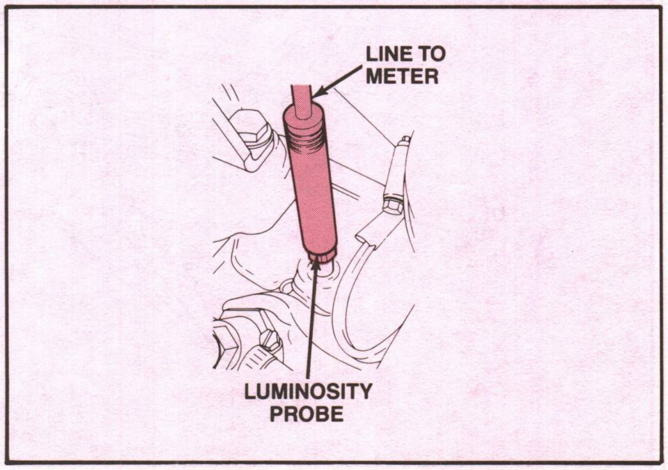


Figure 32 — Luminosity Probe — Dynamic Timing

A magnetic pick-up, installed in the timing quadrant (Figure 33), detects a scribe line on the surface of the vibration damper, and provides information on engine position and engine speed.

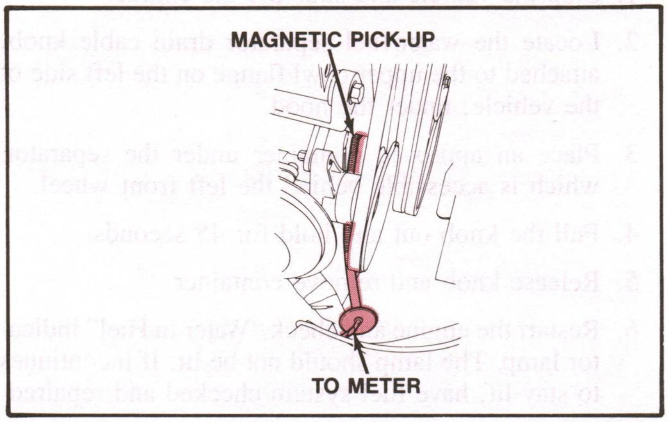


Figure 33 — Magnetic Pick-up — Dynamic Timing

Information from the light sensitive probe on beginning of combustion, and also from the magnetic pick-up on engine position and speed are both fed into the timing meter and tachometer (Figure 34). A timing readout is given in engine degrees before or after top-dead-center. Engine RPM is also given.

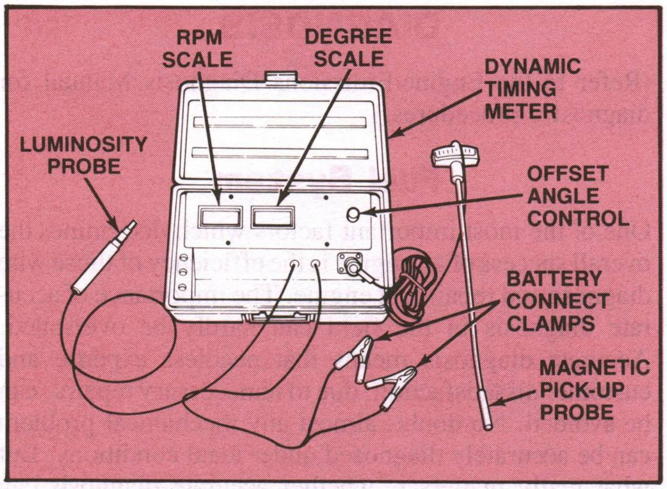


Figure 34 — Dynamic Timing Meter

The actual timing readout is affected by the cetane value of the fuel and altitude. Compensation values for these factors are included in the specification chart.

ADJUSTMENTS

Dynamic Injection Pump Timing Procedure

1. Run engine until normal operating temperature is maintained.
2. Stop engine and install dynamic timing meter Tool No. 78-0100 by placing magnetic pickup in timing pointer probe hole.
3. Disconnect #1 cylinder glow plug wire and remove glow plug using Tool No. D83T-6002-A. Install luminosity probe and tighten to 12 ft.-lbs. (16 N•m). Install photocell over probe.
4. Connect dynamic timing meter to battery.

   NOTE: Insure that all wire leads are located away from the front accessory drive belts.

5. With transmission in neutral and rear wheels off the ground, start engine, and using Tool No. 14-6302 set engine speed to 1400 RPM with no accessory load. Observe dynamic timing on meter.

   NOTE: Refer to specification chart to obtain correct timing in degrees. If the cetane value is not known, obtain a fuel sample and check cetane value with the tester supplied with Tool 78-0100.

6. If dynamic timing is not within ± 2° of specification, adjustment of pump timing is required.
7. Turn engine "Off." Break torque on three nuts attaching injection pump to pump mounting adapter with Tool T83T-9000-B.
8. Install rotating Tool T83T-9000-C on front of pump and rotate clockwise (when viewed from front of engine) to retard, and counterclockwise to advance by lightly tapping with a rubber mallet. 0.1° of dynamic timing is approximately 1.0 mm of timing mark movement.
9. Remove rotating tool and tighten nuts to specifications. Start engine and recheck timing to verify setting. Repeat steps 7 through 9 as required to set timing to ± 1° of the specification.
10. Turn engine "Off." Remove dynamic timing components. Lightly coat glow plug thread with anti-seize compound and install to specification. Connect glow plug wire.

Dynamic Timing Specification Chart Engine at normal operating temperature, 1400 rpm and no load		
Cetane Value	Altitude	
	0-3000 Ft.	3001 Ft. and Up
50-47	4° ATDC①	5° ATDC①
46-43	5° ATDC①	6° ATDC①
42-38	6° ATDC①	7° ATDC①

①ATDC — After top dead center.

Static Injection Pump Timing Procedure

Static injection timing is used to set the **initial** injection pump timing as follows:

1. **Break torque** on three nuts attaching injection pump to pump mounting adapter with Tool T83T-9000-B.
2. Install rotating Tool T83T-9000-C on front of pump and rotate injection pump to align timing mark on injection pump mounting flange, with mark on pump mounting adapter (Figure 35).

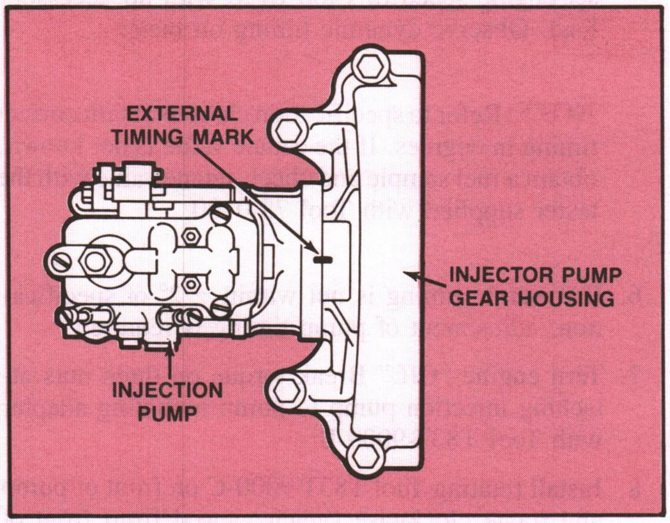


Figure 35 — Injection Pump Timing Marks

3. Remove rotating tool and tighten nuts to specification. Visually recheck timing to verify that marks are aligned.

Water/Fuel Separator

F-SERIES

1. Stop the vehicle and shut Off the engine.

   NOTE: Failure to shut off the engine prior to draining separator will cause air to enter the fuel system.
2. Unscrew the vent 2-1/2 to 3 turns. The vent is located on the top center of the fuel/water separator unit.
3. Unscrew the water drain located on the bottom of the fuel/water separator 1-1/2 to 2 turns and drain water. Use an appropriate container.
4. After water is completely drained, close the water drain fingertight.
5. Tighten the vent until snug, then turn it an additional 1/4 turn.
6. Restart the engine and check "Water in Fuel" indicator lamp. The lamp should not be lit. If it continues to stay lit, have fuel system checked and repaired.

NOTE: F-Series production models will incorporate a drain hose to allow water to flow directly into an approved container placed under the vehicle.

E-SERIES

1. Stop the vehicle and shut Off the engine.
2. Locate the water/fuel separator drain cable knob, attached to the upper cowl flange on the left side of the vehicle, under the hood.
3. Place an approved container under the separator, which is accessible behind the left front wheel.
4. Pull the knob out and hold for 45 seconds.
5. Release knob and remove container.
6. Restart the engine and check "Water in Fuel" indicator lamp. The lamp should not be lit. If it continues to stay lit, have fuel system checked and repaired.

The electrical sensor is the only replaceable item on the water/fuel separator. This assembly is threaded into the top of the separator. The remainder of the water/fuel separator is serviced as a complete unit.

CAUTION: When draining the water/fuel separator, the water must be drained into an approved container.

DIAGNOSIS

(Refer to the Engine/Emissions Diagnosis Manual for diagnostic procedures.)

Fuel System

One of the most important factors which determines the overall success of an engine is the efficiency of those who diagnose and repair that engine. The importance of accurate diagnosis in the field can hardly be overstated. Accurate diagnosis means that needless expense and customer dissatisfaction, due to unnecessary repairs, can be avoided. No doubt, almost any mechanical problem can be accurately diagnosed under ideal conditions. But what really matters is whether accurate diagnosis can become the norm under everyday conditions. Much of the long term success and acceptance of an engine is actually determined by the efficiency of service managers and mechanics. The Engine Performance Chart, which comes in pads of 100 sheets is a useful tool for the mechanic. The mechanic takes it right to the job with him and uses it as a check list. The chart begins with those items which are the high frequency, easy to diagnose causes of the problem, and progresses to the low frequency, hard to diagnose causes of the malfunction. Use of this chart will promote rapid as well as accurate diagnosis. The Engine Performance Chart concept has been used extensively by the Diesel Engine Manufacturer for a number of years.

NOTE: At the time of printing, the Engine Performance Chart was not available to be included into this training manual. This training program will give general instructions on diagnosis of fuel system related problems. These steps will be similar to the steps which will be contained in the Engine Performance Chart.

NOTE: If a problem is found, repair as required. If this corrects the customer's complaint, it will not be necessary to proceed to the next step. If the complaint is not corrected, proceed to the next step.

NOTE: If the problem is hard starting, first refer to the Fast Start Glow Plug System Troubleshooting Chart.

NOTE: Under no circumstances should the injection pump be changed, until the Engine Performance Chart procedures have been completely followed through to their entirety. Warranty claims for the injection pump **will not** be accepted unless the Chart/Diagnosis, and all tamper-resistant seals are intact.

1. **External Leakage** — Leakage can be a reason for complaints of low fuel economy, diesel fuel smell or high oil consumption. A leak in the air intake system can shorten engine life, especially under dusty conditions. A coolant leak can result in a complaint of engine overheating.

2. **Exhaust System Condition** — Inspect the exhaust system for kinks or dents which could cause high exhaust backpressure. High exhaust backpressure causes low power and high smoke levels. Working against a high exhaust backpressure, the engine piston becomes less able to clear the cylinder of exhaust during the exhaust stroke. The exhaust gases, which are not forced out during the exhaust stroke, remain in the cylinder and prevent the piston from drawing a full charge of intake air. Without an adequate amount of intake air, the fuel burns poorly resulting in low power and high smoke levels.

3. **Fuel System Pressure Tests**

   A. **Check Fuel Filter Outlet Pressure** — Check the fuel filter outlet pressure at fuel filter, air bleed orifice (located in the elbow at rear of fuel filter header, Figure 36).

   - Pressure OK — Perform Test C.
   - Pressure not OK — Perform Test B.

   B. **Check Fuel Supply Pump Pressure at Vacuum Purge Valve (Figure 36)**

   - Pressure OK — Replace fuel filter and repeat Test A.
   - Pressure not OK — Perform Test C.

   C. **Check Fuel Supply Capacity at Vacuum Purge Valve (Figure 36)**

   Save all sample fuel for further testing.

   - Pressure OK — Volume not OK — Perform Test D.
   - Volume OK — Pressure not OK — Replace fuel pump and repeat Test A.
   - Pressure and volume OK — Perform Step 4.
   - Pressure and volume not OK — Perform Test D.

   D. **Check With Auxiliary Fuel Supply** — Use an auxiliary fuel supply (stored in an approved container) and repeat Test C.

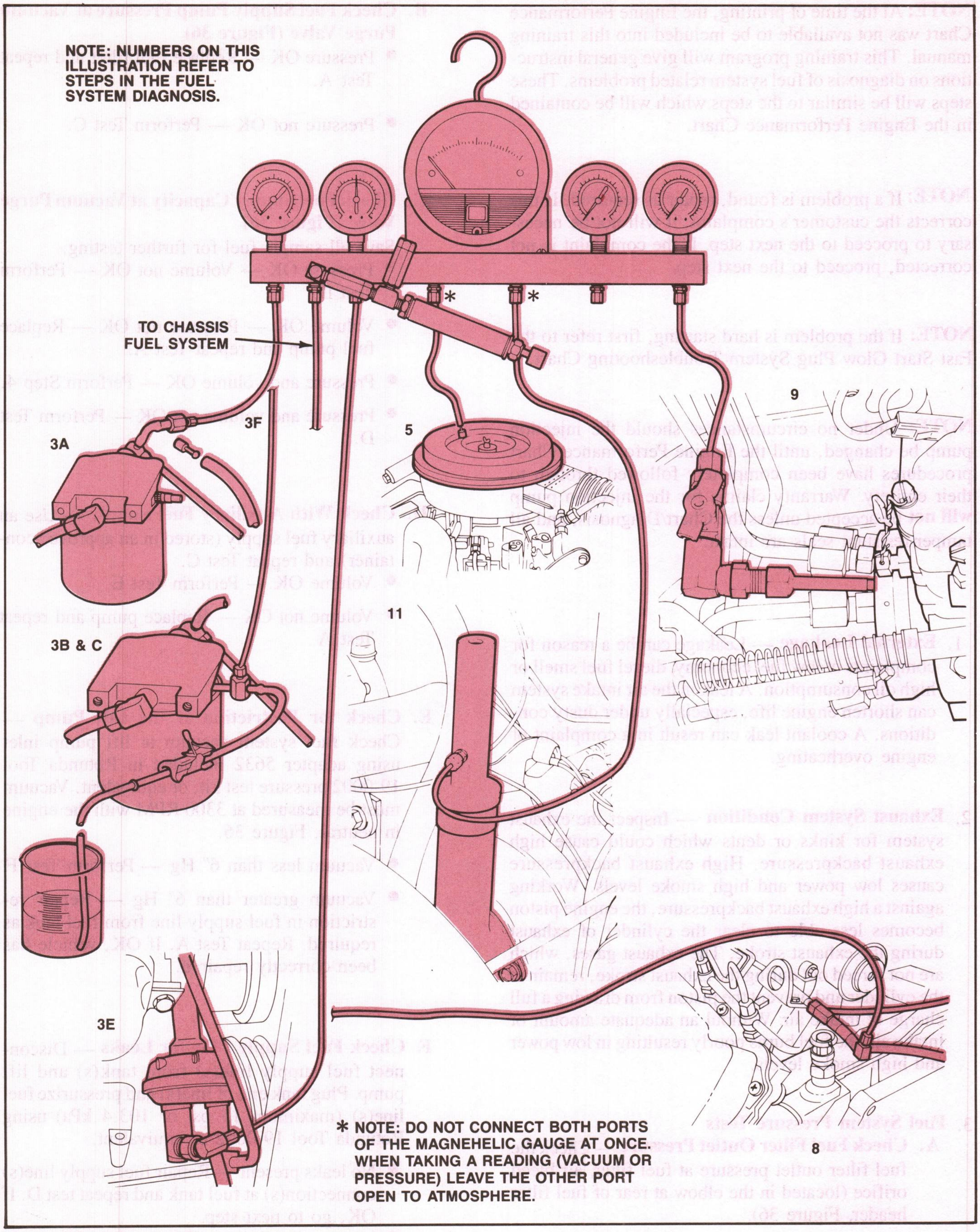
   - Volume OK — Perform Test E.
   - Volume not OK — Replace pump and repeat Test A.

   E. **Check for Restriction at the Lift Pump** — Check fuel system vacuum at lift pump inlet using adapter 5632 included in Rotunda Tool 19-0002 pressure test kit, or equivalent. Vacuum must be measured at 3300 RPM with the engine in neutral, Figure 36.

   - Vacuum less than 6″ Hg — Perform Test F.
   - Vacuum greater than 6″ Hg — Repair restriction in fuel supply line from fuel tank as required. Repeat Test A. If OK, vehicle has been correctly repaired.

   F. **Check Fuel Supply Line for Leaks** — Disconnect fuel supply line(s) from tank(s) and lift pump. Plug tank end of line(s) and pressurize fuel line(s) (maximum 15 psi or 103.4 kPa) using Rotunda Tool 19-0002 or equivalent.

   - No leaks present — Repair fuel supply line(s) connection(s) at fuel tank and repeat test D. If OK, go to next step.
   - Leaks are present — Repair all leaking connections and repeat Test F. If OK, go to the next step.


NOTE: NUMBERS ON THIS ILLUSTRATION REFER TO STEPS IN THE FUEL SYSTEM DIAGNOSIS.

* NOTE: DO NOT CONNECT BOTH PORTS OF THE MAGNEHELIC GAUGE AT ONCE. WHEN TAKING A READING (VACUUM OR PRESSURE) LEAVE THE OTHER PORT OPEN TO ATMOSPHERE.

Figure 36 — Fuel System Pressure Tests

4. **Check for Fuel Quality** — Every diesel needs clean fuel, free of air or water, in order to produce rated power **(water can be hazardous to a diesel engine).** Make sure it is the grade recommended for the temperature conditions it is operating in. Ambient temperature has an effect on the fuel so proper fuel is required for proper operation of the engine. If the injection pump is receiving air with the fuel, performance will be adversely affected. Any fuel link leakage on the suction side (from fuel tank to fuel pump) will result in aerated fuel. If in doubt about the fuel in the tank or aerated fuel, try running the engine off a can of fuel known to be good, and then see if performance improves.

   A. **Check for Fuel Contamination** — Examine a sample of the fuel (including bottom of container) in a clear container for particles or other liquid contaminates, such as water.

   - No contamination — Perform Test B.
   - Contamination found — Clean and/or repair fuel system as required.

   B. **Check Fuel Cetane Level**

   - Cetane value OK — Go to the next step.
   - Cetane value not OK — Inform owner to change fuel source.

5. **Air Cleaner Maximum Restriction** — Often a low power, excessive smoke and poor fuel economy complaint is simply due to a dirty air cleaner. In this test, the gauge adapter is installed in the air cleaner lid (Figures 36, 37 and 38). As the air cleaner accumulates dirt, restriction to air flow increases.

NOTE: Maximum allowable restriction is 25 inches of water (H_2O). It takes 13.6 inches of water (H_2O) to equal one inch of mercury.

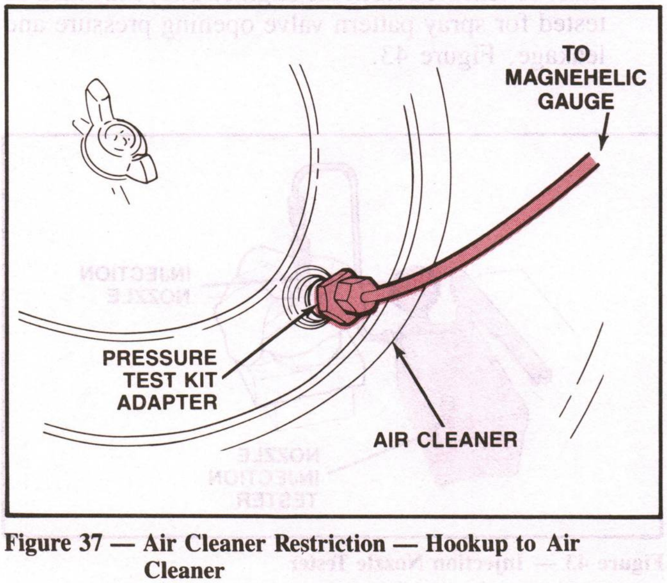


Figure 37 — Air Cleaner Restriction — Hookup to Air Cleaner

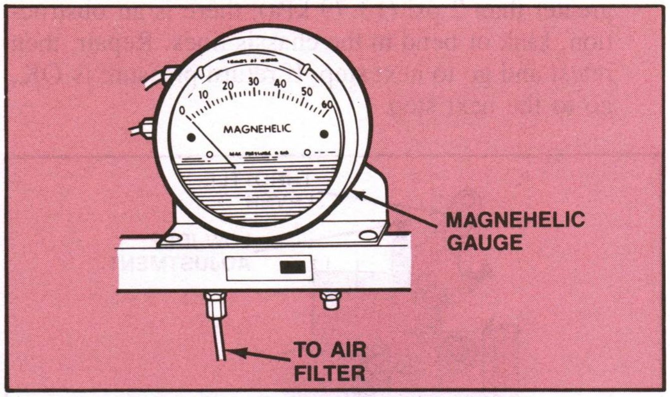


Figure 38 — Air Cleaner Restriction — Magnehelic Gauge

NOTE: Do not connect both ports of the magnehelic gauge at once. When taking a reading (vacuum or pressure) leave the other port open to atmosphere.

6. **Accelerator Linkage** — To perform this test, the engine must be shut off. If the throttle lever does not reach full rated speed stop, (Figure 39) vehicle top speed and pulling power will suffer. The solution is to readjust vehicle linkage.

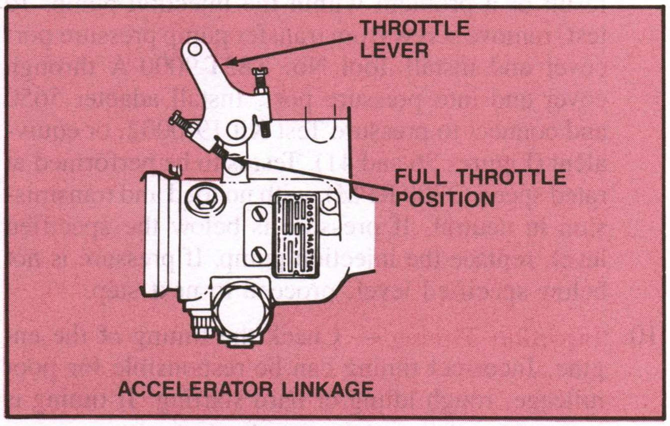


Figure 39 — Accelerator Linkage

7. **Engine Speed (RPM) Checks**

   A. **Low Idle (RPM)** — Complaints of stalling or rough running can be the result of incorrect low idle speed. Low idle speed is adjusted at the low idle adjusting screw (Figure 40). Low idle speed is measured with manual transmission in neutral, and automatic transmission in drive. The engine must be at normal operating temperature with all accessories "Off." Idle speed must be 675 (±25) RPM.

8. **Check Fuel System Return Hose for Restriction** — For this test, insert adapter 5663 included in Rotunda Tool 19-0002, or equivalent, at the rear of the engine where the return line from the injectors connects to the main chassis return line going back to the fuel tank (Figure 36). If return line pressure is

greater than 2 psi (13.79 kPa), there is an obstruction, kink or bend in the chassis lines. Repair, then retest and go to next step. If return pressure is OK, go to the next step.

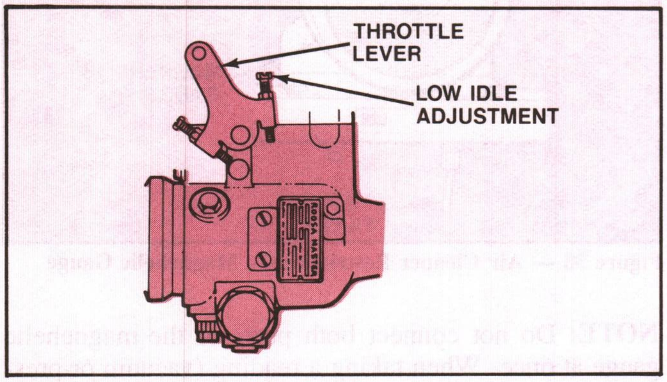


Figure 40 — Low Idle Adjustment

9. **Check Transfer Pump Pressure** — Transfer pump pressure is that fuel pressure which is available to charge the injection plungers. If the pressure is below specified level, low power will be a result. If specified reading could be obtained in Step 3A, but transfer pump pressure is low, it is most probably the result of a problem within the injection pump. To test, remove screw from transfer pump pressure port cover and install Tool No. T83T-9000-A through cover and into pressure port. Install adapter 5650 and connect to pressure Test Kit 19-0002, or equivalent (Figures 36 and 41). Test is to be performed at rated speed (3300 RPM), with no load and transmission in neutral. If pressure is below the specified level, replace the injection pump. If pressure is not below specified level, proceed to next step.
10. **Injection Timing** — Check the timing of the engine. Incorrect timing can be responsible for poor mileage, rough idling or hard starting. If timing is incorrect, set timing to specifications.

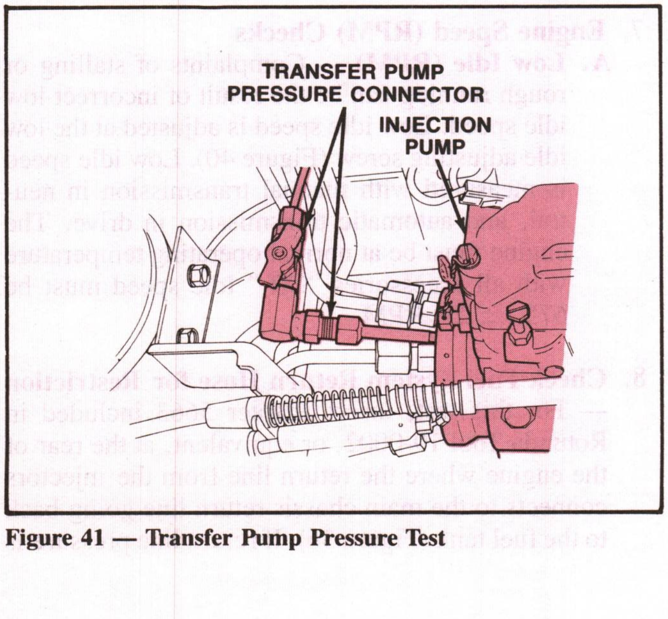


Figure 41 — Transfer Pump Pressure Test

11. **Crankcase Pressure** — This test measures the amount of crankcase blowby. This is accomplished by causing all the blowby to be directed through an orifice of a specified diameter (Figures 36 and 42). Pressure upstream of the orifice is then measured. More blowby will create higher pressures. Crankcase pressure is measured in inches of water (H_2O). Periodic checking of this pressure will evaluate internal engine power cylinder wear. Positive crankcase pressure is normal and is intentionally designed into the engine. Readings recorded beyond specifications signal a need to completely review engine condition. Crankcase pressure readings plus rate of oil consumption should be used to evaluate engine condition.

NOTE: Do not connect both ports of the magnehelic gauge at once. When taking a reading (vacuum or pressure) leave the other port open to atmosphere.

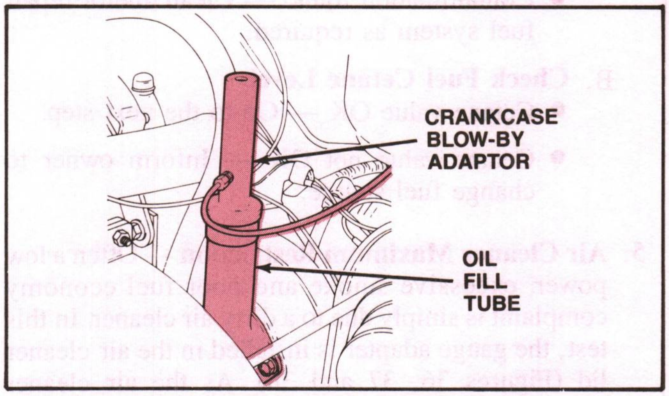


Figure 42 — Crankcase Pressure Test Hookup

12. **Test Injection Nozzles** — This is a functional test of injection nozzle performance. The injection nozzles must be removed from the engine. They may then be tested for spray pattern valve opening pressure and leakage, Figure 43.

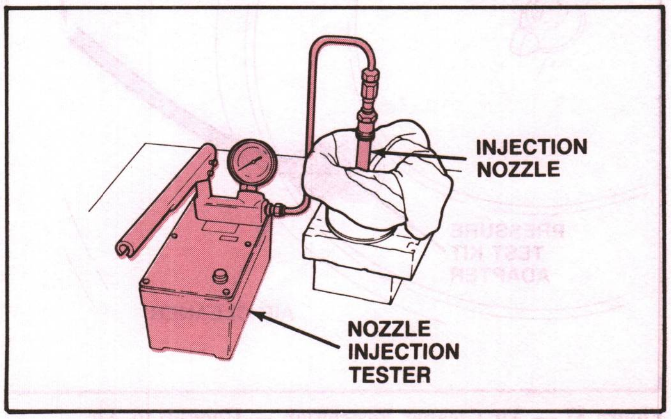


Figure 43 — Injection Nozzle Tester

Some smoke from a diesel is normal and expected, this Section describes what is normal and expected exhaust smoke. Diesel exhaust smoke can be classified into two categories according to visual appearance. The first category is blue-white smoke.

- White smoke may be observed at engine start up whether the engine is up to operating temperatures or not. This start up smoke will be observed in warm as well as cold weather and should last no longer than a minute after vehicle is driven.
- When ambient temperature is below 10°C (50°F), white smoke can return after the engine warm up period due to extended idling. This is because the combustion chambers cool down during periods of extended idling time.
- Blue smoke is an indication of oil burning.

The second category of diesel exhaust smoke is black smoke. Black smoke is unburned fuel which occurs whenever the engine is working hard. The engine works hard when it is going up a steep grade, pulling a trailer, carrying a heavy load, or during acceleration while lugging a heavy load. More black smoke will be observed at higher altitudes than at lower altitudes. If black smoke is observed while the engine is idling (at low altitude) or under normal driving conditions, the problem should be diagnosed as soon as possible.

Injection Nozzles

Where ideal conditions of good combustion, specified engine temperature control and absolutely clean fuel prevail, nozzles require little attention.

Nozzle trouble is usually indicated by one or more of the following symptoms:

- Smoky exhaust (black)
- Loss of power
- Misfiring
- Increased fuel consumption
- Combustion knock
- Engine overheating

Where faulty nozzle operation is suspected, on an engine that is misfiring or puffing black smoke, a simple test can be made to determine which cylinder is causing the difficulty.

- With the engine running at a speed that makes the problem most pronounced, momentarily loosen the high pressure fuel inlet line connection on one nozzle assembly sufficiently to "cut-out" the cylinder (one half to one turn). Then tighten nut to specification. Check each cylinder in the same manner. If one is found where loosening makes no difference in the irregular operation or causes puffing black smoke to stop, the injection nozzle for that cylinder should be tested.

After removing the nozzle(s) from the engine they should be tested for proper operation on a nozzle test stand. This test will give valuable information regarding the condition of the nozzle(s). A clean work bench, clean washing fluid containers, clean tools and clean hands are all essential to produce satisfactory results.

Figure 43 shows the Rotunda Injector Nozzle Tester Model No. 14-6300. The nozzle is mounted to this tester and the test procedure is as follows:

- **Prepare stand for making tests.** Fill the stand reservoir with clean recommended test fluid. Open the tester valve slightly and operate tester handle to expel air from tester and outlet pipe. Operate the tester until solid fluid (without air bubbles) flows from the end of outlet pipe. Close the tester valve. Important: It is recommended to test nozzles before cleaning them.
- **Connect injection nozzle to test stand.** Care should be taken to avoid "cross-threading." Tighten connector nut securely with end wrench. Nozzle adapter 14-300-A which is supplied with tester has right hand threads to nozzle assembly and left hand threads to tester piping.
- **Bleed air from nozzle.** Open the stand valve and operate the tester handle for several quick strokes to expel (bleed) air from injection nozzle. Fluid should spray from the spray holes in nozzle tip.

WARNING

Always wear approved safety glasses when operating the tester! Volatile liquids can be extremely flammable when vaporized. Avoid any condition (sparks, open flames, lit cigarettes, etc.) which might ignite the fluid used during the test procedure. The only liquid approved for use in this tester is SAE Calibration Fluid No. #208629, or equivalent calibration fluid (SAE J967D or ISO 4113).

When a nozzle is being tested or is in operation, keep hands and other parts of the body away from the spraying nozzle. The liquid spray leaves the nozzle tip with sufficient force to penetrate the skin and cause serious injury. The nozzle tip should be enclosed in a transparent receptacle if available.

- **Check nozzle opening pressure.** Open the gauge valve and build up line pressure by slowly depressing handle until nozzle opens (sprays fuel). Observe the gauge to determine pressure at which nozzle opens. Then, repeat operation until accurate opening pressure is established. Normal operating pressure of the nozzle is 2100-2150 psi (14,480-14,824 kPa). The service level is 1850 psi (12,756 kPa).

NOTE: Chatter will vary from nozzle to nozzle as will the sound. While nozzle chatter is acceptable, a lack of chatter is not a criteria for considering the nozzle to be defective.

- **Check for tip leakage.** Wipe the nozzle tip dry. Operate test pump to maintain pressure at 200 psi (1379 kPa) below opening pressure of the nozzle. Nozzle tip should remain dry without an accumulation of fuel drops at spray holes. A slight wetting, after about 5 seconds, is permissible if no droplets are formed.

NOTE: Do not wipe tip with fingers, as this will tend to draw the fuel present in the sac hole, through the orifice, and falsely indicate a leak and rejection of a good nozzle.

- **Check fuel leak-off.** Operate the test pump in quick strokes and observe flow of fuel from return ports of nozzle. A very slight leak-off, one to two drops per stroke, is normal. If fuel squirts from fuel return port when test pump is operated, nozzle is faulty and must be replaced.
- **Check spray pattern.** Operate test pump in smooth, even strokes and observe pattern of fuel spraying from nozzle. Only the first 3 inches (76mm) of spray from the end of the nozzle is important. The spray should be finely atomized in an even, straight pattern (Figure 44). The nozzle is damaged if the spray pattern is lopsided (not concentric with nozzle axis), uneven, if fuel comes out in droplets or in a solid stream as shown in Figure 44. If nozzle fails spray pattern test, clean nozzle and repeat test.

If nozzle passes the prior tests, it is suitable for further service in the engine, following external cleaning and removal of accumulated carbon. Nozzles showing irregular spray pattern, leakage at nozzle tip spray holes, excessive fuel leak-off or opening pressure below minimum permissible limit, should be repaired or replaced depending upon the warranty status.

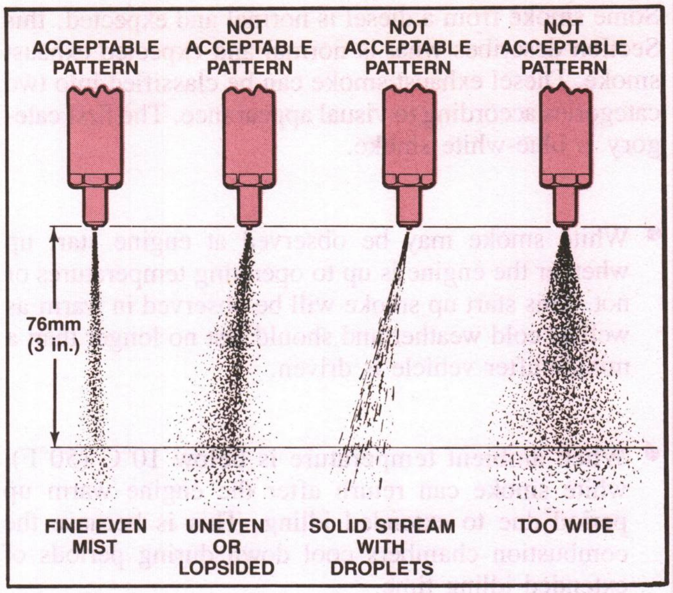


Figure 44 — Injection Nozzle Spray Pattern

ELECTRICAL (GLOW PLUG) SYSTEM

The 6.9L diesel engine utilizes an electrical glow plug system to aid in the starting of the engine. The function of this system is to pre-heat the air inside the combustion chamber to aid ignition of the fuel.

The system consists of eight glow plugs (one for each cylinder), control switch, power relay, after glow relay. This includes a wait lamp latching relay, wait lamp and a wiring harness, which incorporates eight fusible wires (one for each glow plug) located between the wiring harness and the glow plug terminal. The system is activated by the ignition switch being turned to the **ON** position.

A description of each component follows:

- **Glow Plugs** (Figure 45) — The glow plugs used have a 6 volt rating. By using 6 volt glow plugs, the wait time before a cold engine can be started is reduced considerably, since the 6 volt glow plugs heat up extremely fast with 12 volts being applied. When 12 volts are applied to the glow plug, rapid heating of the glow plug tip occurs, which in turn heats up the air inside the pre-chamber. As the fuel is injected into the pre-chamber, it is ignited. The rapid burning of the fuel forces it through the small opening in the pre-chamber into the cylinder where it mixes with more hot air and a second combustion takes place. To prevent overheating of the glow plug, a cycling device is used in the circuit.

CAUTION: Extreme caution must be taken to avoid bypassing the control assembly. The glow plugs can be destroyed if subjected to a direct 12 volt charge for a period of over 15 seconds.

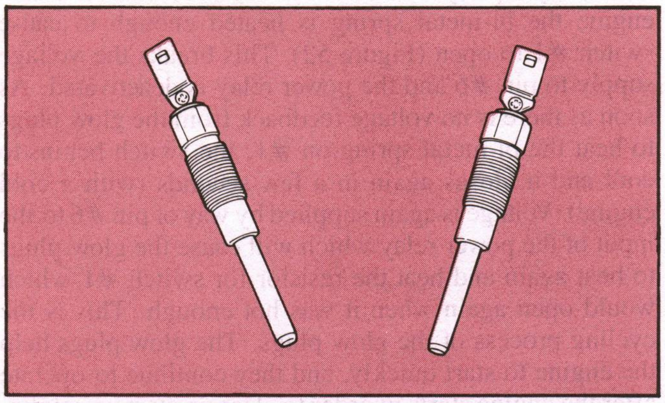


Figure 45 — Glow Plugs

- **Control Switch** (Figure 46) — The control switch is located on the rear of the engine. It senses the temperature of the engine coolant and determines the length of time that the glow plugs will be on. The length of time varies between 4-10 seconds.

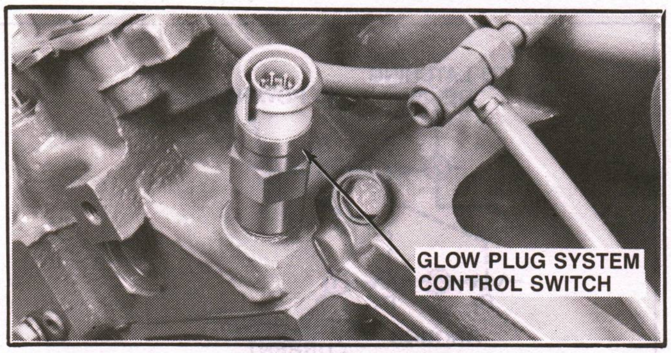


Figure 46 — Control Switch

- **Power Relay** (Figure 47) — Located on the right, inner fender in the engine compartment, the power relay (when activated by control switch) allows battery voltage (12V) to flow to glow plugs.

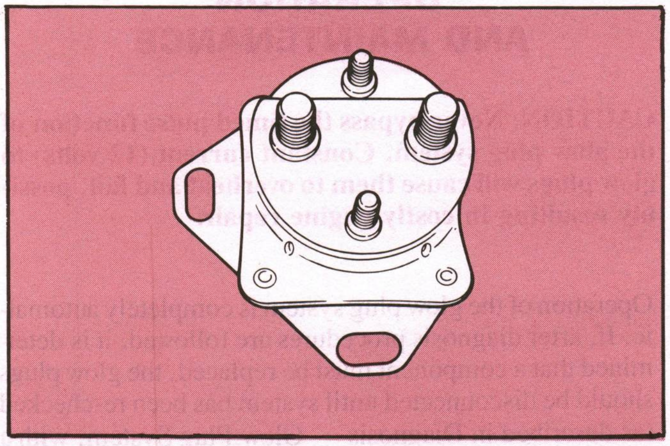


Figure 47 — Power Relay

- **After Glow Relay** — Activated by the alternator, after the engine has started, current flows through the relay which is used as a safety relay to cut power to the glow plugs.
- **Wait Lamp Latching Relay** — Controls wait lamp, and turns it **On** and **Off**.
- **Wait Lamp** — Located in the instrument cluster, this informs driver when the engine is ready to be started. The wait lamp will come on when the ignition switch is in the **On** position, only when the engine is below 165°F (91°C). For a bulb check, the bulb will come on when the ignition switch is in the **Start** position.
- **Wiring Harness** (Figure 48) — Connects all components of the glow plug system. The harness incorporates eight fusible wires (one for each glow plug) as a safety device to protect against a direct short of the glow plugs. If a fusible wire should become damaged, it will be necessary to replace the complete glow plug wiring harness.

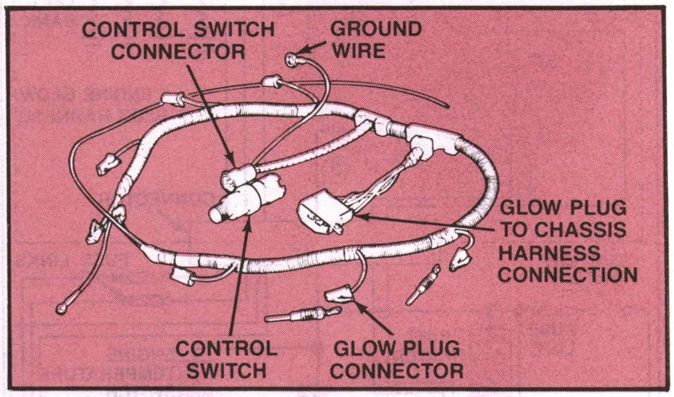


Figure 48 — Glow Plug System Wiring Harness

NOTE: The chassis wiring harness to the glow plug wiring harness also incorporates two replaceable fusible links, one for each glow plug bank, (circuit 471 OR-LT GRN DOTS right bank and circuit 337 OR-WH STRIP left bank).

SYSTEM DESCRIPTION

Refer to Figures 49 and 50 for electrical schematic of the glow plug system and the control switch.

When the ignition switch is turned to the **On** position:

- Power flows through the ignition switch to pin 3 of the control switch.
- The power then flows through resistor R3, switch S2, pin No. 2 (to latching relay), switches S1, S3 and pin 6 (to power relay), (Figure 51).

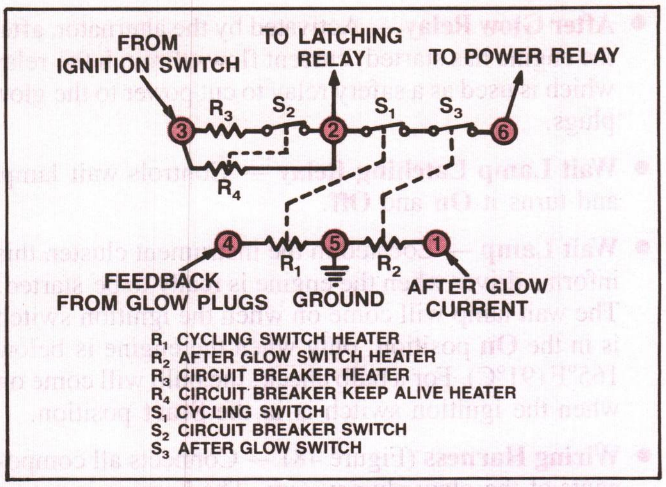


Figure 49 — Control Switch Electrical Schematic

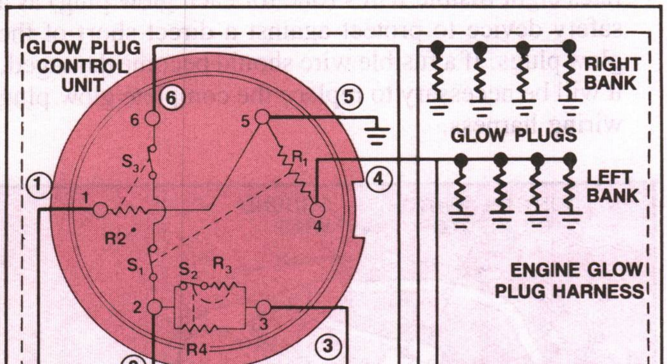


Figure 50 — Glow Plug System Electrical Schematic

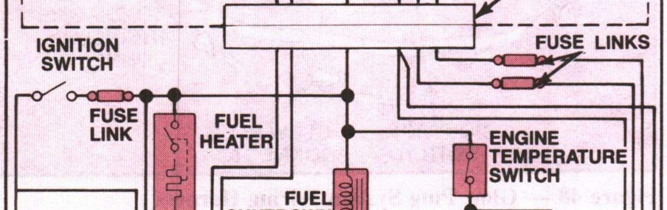


Figure 51 — Control Switch Circuit

While the glow plugs are heating, the resistance heater on switch #1 is also being supplied voltage from the output terminal of the power relay. This starts heating the bi-metal spring on switch #1 (this bi-metal spring heats and cools very rapidly) and after about 10 seconds on a cold engine the bi-metal spring is heated enough to cause switch #1 to open (Figure 52). This breaks the voltage supply to pin #6 and the power relay is deactivated. As soon as there is no voltage feedback from the glow plugs to heat the bi-metal spring on #1, the switch begins to cool and it closes again in a few seconds (with a cold engine). Voltage is again supplied by way of pin #6 to the input of the power relay which will cause the glow plugs to heat again and heat the resistor for switch #1 which would open again when it was hot enough. This is the cycling process of the glow plugs. The glow plugs help the engine to start quickly, and they continue to operate after the engine starts in order to clear up start up smoke. This cycling would continue indefinitely if it was not for the after glow signal from the alternator, received after the engine starts. This voltage signal starts heating the bi-metal spring on switch #3. After 20 to 90 seconds of receiving voltage, the bi-metal spring will have been heated enough to cause switch #3 to open and shut the glow plug system off.

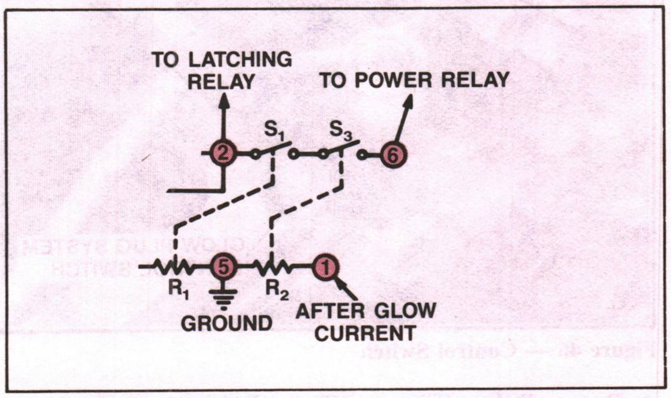


Figure 52 — Control Switch Circuit

OPERATION AND MAINTENANCE

CAUTION: Never bypass the timed pulse function of the glow plug system. Constant current (12 volts) to glow plugs will cause them to overheat and fail, possibly resulting in costly engine repair.

Operation of the glow plug system is completely automatic. If, after diagnosis procedures are followed, it is determined that a component must be replaced, the glow plugs should be disconnected until system has been re-checked (as described in Diagnosis — Glow Plug System, with a test lamp) for correct operation.

DIAGNOSIS

Glow Plug System

NOTE: If the problem is hard starting, follow the procedures for troubleshooting the glow plug system prior to troubleshooting the fuel system.

The Fast Start Glow Plug System Diagnostic Procedure describes the method for accurately monitoring the operating of the fast start system. Use of these procedures will help in correcting any problem as fast and efficiently as possible. Results of one basic diagnostic test will direct you to one of six specific diagnostic procedures.

NOTE: At the time of printing, the Fast Start Glow Plug System Diagnostic Chart was not available to be inserted into this training manual. This training program will give general instructions on diagnosis of fast start system problems. These steps will be similar to the steps contained in the diagnostic chart.

BASIC DIAGNOSTIC TEST

To diagnose the glow plug system it will be necessary to connect a 12 volt test lamp between the power relay output (to glow plugs) and ground (Figure 53). Check test lamp signals as follows:

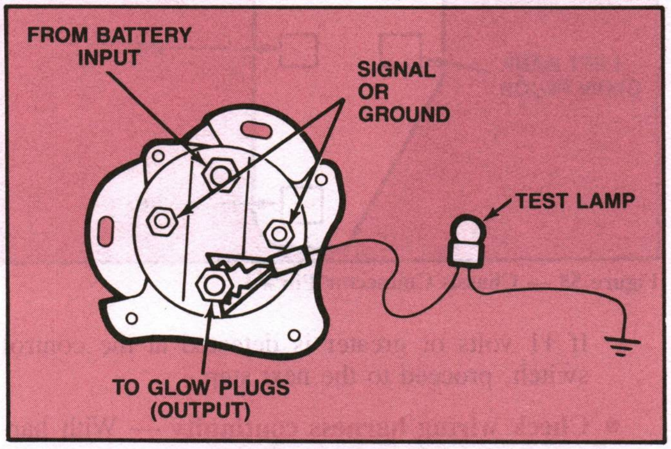


Figure 53 — Test Lamp Connection

Engine cold, ignition switch ON, engine not started

- Test lamp will light when engine switch is turned on.
- Lamp will be lit for 4 to 10 seconds (depending upon engine coolant temperature).
- Test lamp will then repeat **ON-OFF** cycle.

After engine is started

- Test lamp continues to repeat **ON-OFF** cycle for 20 to 90 seconds.
- Lamp will cycle for a maximum of 90 seconds after engine is started.

Engine stopped, then restarted

- Test lamp will light if coolant temperature at the control switch probe has fallen below 165°F (91°C) between starts. The system will operate for a shorter period of time than with a completely cold engine.
- Test lamp will remain off if coolant at the control switch probe is at 165°F (91°C) or higher.

Using the results of the basic diagnostic test, you can identify one of the six diagnostic procedures to resolve the problem. A basic test result is described at the start of each diagnostic procedure. Pick the procedure that best fits your basic test results. Then proceed with the particular tests. After completing a specific procedure, repeat the basic diagnostic test to verify that the system is operating properly.

NOTE: Whenever disconnecting the glow plug wires from the glow plugs, insulate them from contacting the engine and causing a possible short circuit.

NOTE: After completing any of the following procedures and replacing any of the glow plug system components, retest the system for correct operation.

1. TEST LAMP SIGNAL IS CORRECT

- **Check voltage to each glow plug** — Remove leads from glow plugs. Turn ignition switch to **On** (with test lamp still connected to power relay). Check voltage between each glow plug lead and ground. There should be 11 volts minimum at each lead whenever test lamp lights. If voltage is not detected at any or all leads, check fusible links, repair vehicle harness or replace glow plug harness.
- **Check glow plug resistance** — Turn ignition switch **Off**. Measure resistance between glow plug terminal and shell. Replace any glow plug with a reading of 2 ohms or more. Less than 2 ohms is OK. Glow plug system is functioning properly if both tests check out correctly.

2. TEST LAMP ON CONTINUOUSLY

CAUTION: Remove all leads from glow plugs before proceeding with this test. Do not attach leads to glow plugs until system has been rechecked for correct operation.

- **Isolate damaged component** — With test lamp still connected to power relay, turn ignition switch to **On. DO NOT START ENGINE.** Remove harness plug from control switch. If test lamp goes out, replace control switch (Figure 46). If test lamp stays on, remove signal lead (lead from control switch) from power relay (Figure 53). If test lamp goes out, replace glow plug wiring harness. If test lamp stays on, replace the power relay.
- **Check for damage to glow plugs and harness** — Check the continuity of the fusible links in wiring harness. Ignition switch **Off**, check the continuity between each glow plug connector and power relay output terminal. If any reading is 1 ohm or more, replace wiring harness. Less than 1 ohm is OK.
- **Check glow plug resistance** — Ignition switch **Off**, measure the resistance between glow plug terminal and shell. Replace any glow plug where resistance is 2 ohms or higher. Less than 2 ohms is OK.

3. LAMP DOES NOT LIGHT

NOTE: This is normal and expected with a warm engine (at or above 165°F or 91°C). If engine is below normal operating temperature, turn ignition **Off**. Wait five minutes, then turn ignition **On** again. Observe monitor lamp. If lamp still does not light, proceed with this test. If lamp now lights, go to Test 5 — Monitor Lamp Lights when Ignition is First Turned On, then Goes OFF and Stays OFF for an Extended Period of Time.

- **Check battery state of charge** — If the battery will crank the engine, it will operate the glow plug system.
- **Replace fuse in circuit from ignition switch to control switch** — Retest the system. If the system still will not function, but fuse did not blow, proceed to next step. If the system will not function and replacement fuse blew, remove signal lead from the power relay, replace fuse, and turn ignition switch to **On**. If fuse does not blow — replace the power relay. If fuse blows again, separate glow plug harness to chassis harness connector. Replace fuse, turn ignition **On.** If fuse blows, repair vehicle wiring. If fuse does not blow, replace glow plug wiring harness.
- **Check battery power to power relay** — Ignition switch **Off.** Connect voltmeter between power relay battery terminal (input) and ground. If less than 11 volts **is** detected, repair wiring between battery and power relay. If 11 volts or greater is detected, check power to control switch (next step).
- **Check power to control switch** — With the ignition switch in **On** position and the harness plug removed from the control switch, check the voltage between pin 3 of the control switch connector (Figure 54), and ground. If a minimum of 11 volts **is not** detected, open glow plug harness-to-chassis connector and test for voltage at pin 3 on chassis side of connector (Figure 55). If a reading of less than 11 volts is **still** detected, repair vehicle wiring. If 11 volts or greater is detected, replace glow plug wiring harness.

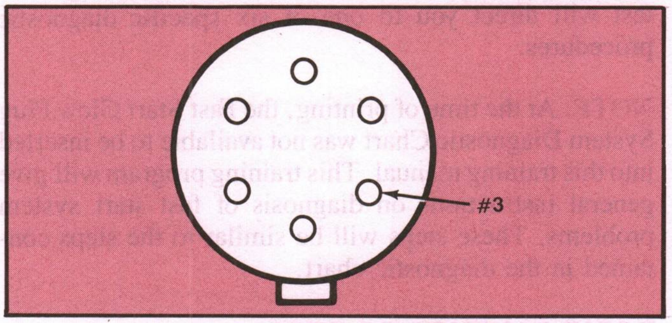


Figure 54 — Control Switch Connector Pin #3

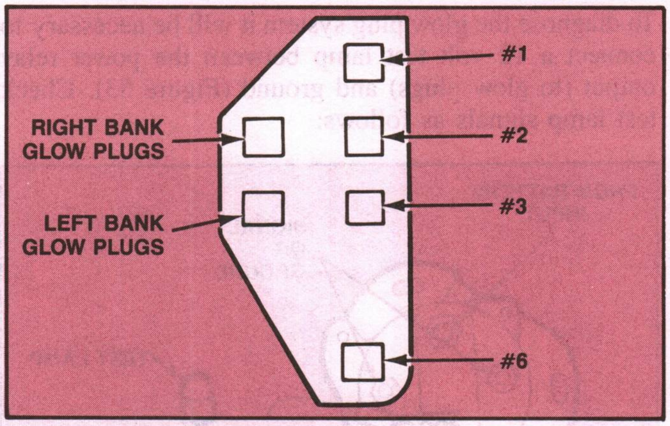


Figure 55 — Chassis Connector Pin #3

If 11 volts or greater is detected at the control switch, proceed to the next step.

- **Check wiring harness continuity** — With harness leads at control switch disconnected, disconnect power relay signal lead, and check continuity between signal lead and pin 6 of the control switch connector (Figure 56).

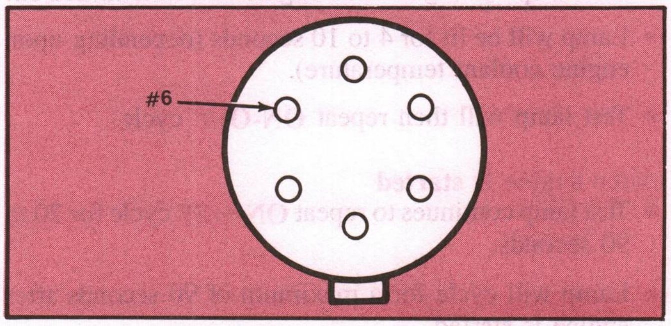


Figure 56 — Control Switch Connector Pin #6

If less than 1 ohm resistance is observed, proceed to the next step.

If the resistance is 1 ohm or greater, separate glow plug harness to chassis connector and check for continuity between chassis side pin 6 (Figure 57) and the power relay trigger lead. If reading is less than 1 ohm, replace glow plug wiring harness. If reading is greater than 1 ohm, repair the vehicle wiring.

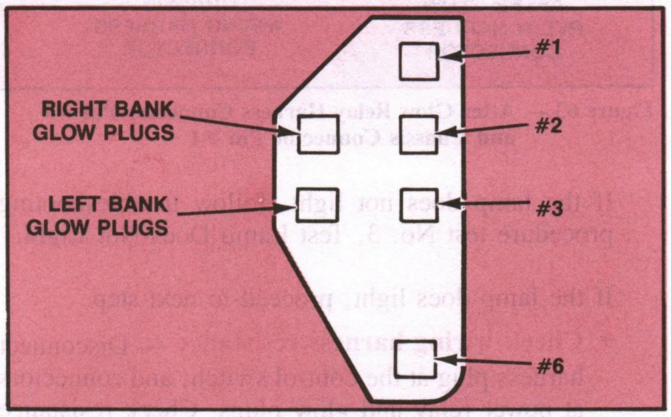
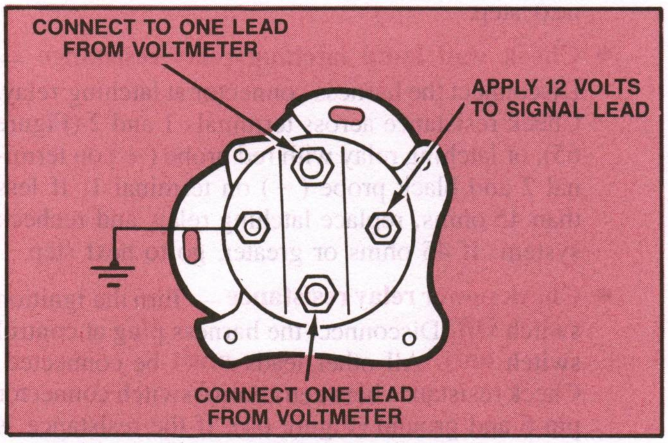


Figure 57 — Chassis Side Connector Pin #6

- **Check power relay for a short** — Disconnect all leads except ground to the power relay. Connect a voltmeter between input and output terminals and apply 12 volts to the signal lead input terminal (Figure 58). If voltage is detected by voltmeter, replace the power relay. If no voltage is detected, proceed to the next step.



CONNECT TO ONE LEAD FROM VOLTMETER
APPLY 12 VOLTS TO SIGNAL LEAD
CONNECT ONE LEAD FROM VOLTMETER

Figure 58 — Checking Power Relay for Short

- **Check function of power relay** — Disconnect all leads to the power relay except ground. Connect ohmmeter across input and output terminals of the power relay (Figure 59). Apply battery voltage to the signal lead input terminal of the power relay. If **less** than 1 ohm resistance, proceed to the next step.

  If 1 ohm or greater, check ground leak or replace the power relay.

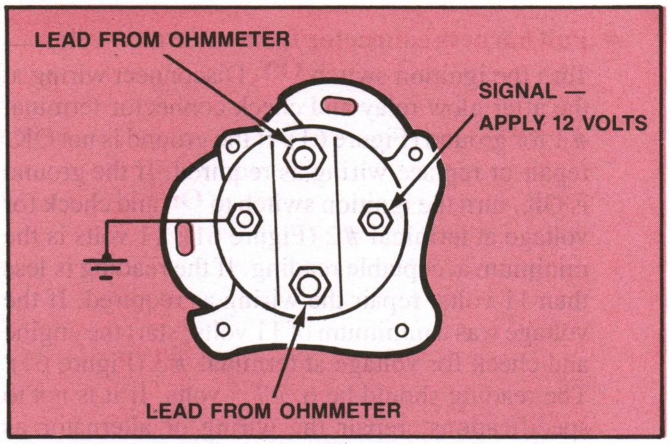


Figure 59 — Checking Power Relay Function

- **Check after glow voltage** — Remove the harness plug at the control switch and connect all leads to power relay. Turn the ignition switch **On — DO NOT START ENGINE.** Check for voltage at control switch harness plug pin 1 (Figure 60). If **no** voltage is detected, replace glow plug control switch. If voltage is detected, repair alternator or vehicle wiring and **replace** after glow relay, as necessary.

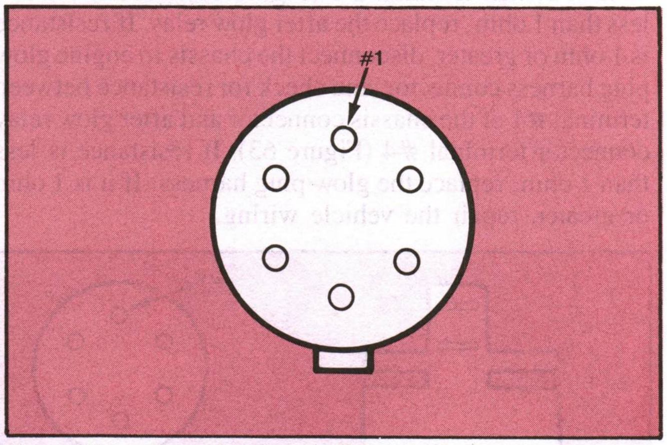


Figure 60 — Control Switch Connector Pin #1

4. TEST LAMP CONTINUES TO CYCLE BEYOND THE MAXIMUM OF 90 SECONDS FOLLOWING ENGINE START

- **Check after glow voltage** — Remove harness plug at the control switch. Start engine and check for voltage at control switch harness plug pin 1 (Figure 60). If after glow voltage reading is 11 volts or more, replace the control switch. Recheck for correct system operation. If after glow reading is less than 11 volts, proceed to next step.

- **Pull harness connector from after glow relay** — Turn the ignition switch **Off.** Disconnect wiring at the after glow relay and check connector terminal #1 for ground (Figure 61). If the ground is not OK, repair or replace wiring as required. If the ground is OK, turn the ignition switch to **On** and check for voltage at terminal #2 (Figure 61). 11 volts is the minimum acceptable reading. If the reading is less than 11 volts, repair the wiring as required. If the voltage was a minimum of 11 volts, start the engine and check for voltage at terminal #3 (Figure 61). The reading should be 6.5-7.5 volts. If it is not to specifications, repair the wiring or alternator as required.

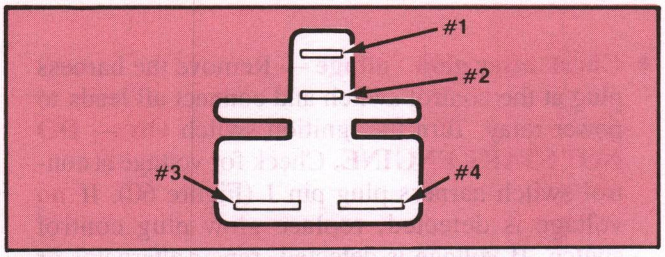


Figure 61 — After Glow Relay Harness Connector

If the harness connector checks out OK, check for resistance between harness connector terminal #4 and control switch terminal #1 (Figure 62). If resistance is less than 1 ohm, replace the after glow relay. If resistance is 1 ohm or greater, disconnect the chassis to engine glow plug harness connector, and check for resistance between terminal #1 of the chassis connector and after glow relay connector terminal #4 (Figure 63). If resistance is less than 1 ohm, replace the glow plug harness. If it is 1 ohm or greater, repair the vehicle wiring.

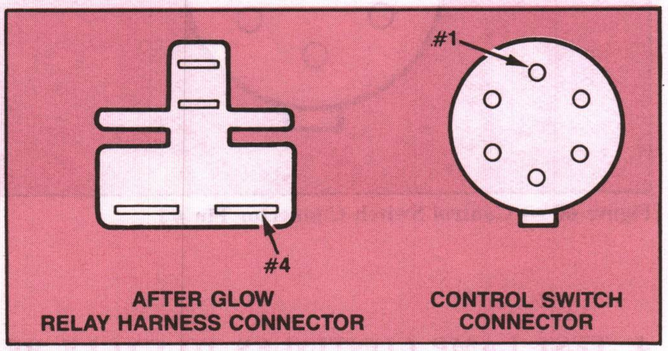


Figure 62 — After Glow Relay Harness Connector Pin #4 and Control Switch Connector Pin #1

5. TEST LAMP LIGHTS WHEN IGNITION IS FIRST TURNED ON, THEN GOES OFF AND STAYS OFF FOR AN EXTENDED PERIOD OF TIME.

NOTE: This is normal and expected with a partially warmed engine (coolant temperature of 140°F [60°C] or above). If the engine is below 140°F (60°C) turn ignition **Off.** Wait five minutes and turn ignition switch to **On** again. Observe test lamp.

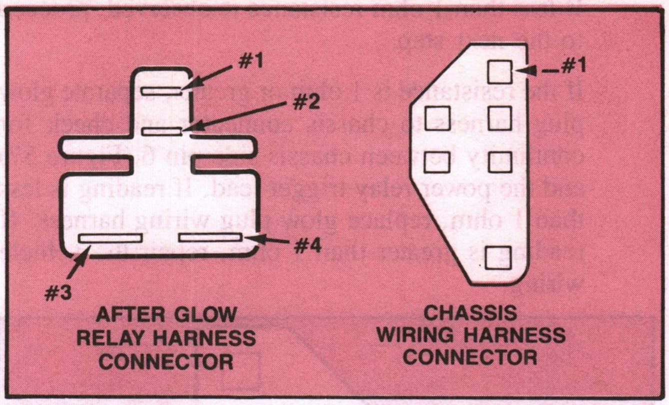


Figure 63 — After Glow Relay Harness Connector Pin #4 and Chassis Connector Pin #1

If the lamp does not light, follow troubleshooting procedure test No. 3, Test Lamp Does Not Light.

If the lamp does light, proceed to next step.

- **Check wiring harness resistance** — Disconnect harness plug at the control switch, and connectors at power relay and glow plugs. Check resistance between the control switch connector pin 4 (Figure 64), and the power relay output terminal connector. If resistance is 1 ohm or greater, replace glow plug wiring harness. If resistance is less than 1 ohm, check for resistance between the control switch connector pin 5 (Figure 64) and a **good** ground. If resistance is 1 ohm or greater, repair harness ground connection, or replace harness as necessary. If resistance is less than 1 ohm, proceed to next step.
- **Check wait lamp latching relay resistance** — Disconnect the harness connector at latching relay. Check resistance across terminals 1 and 2 (Figure 65), of latching relay with red probe (+) on terminal 2 and black probe (−) on terminal 1. If less than 45 ohms, replace latching relay, and recheck system. If 45 ohms or greater, go to next step.
- **Check power relay resistance** — Turn the ignition switch **Off.** Disconnect the harness plug at control switch **only.** All other leads **must** be connected. Check resistance between control switch connector pin 6 and ground (Figure 64). If the resistance is 2.5 ohms or more, proceed to next step. If the resistance is less than 2.5 ohms, replace power relay. Recheck the system for proper operation.
- **Check after glow voltage** — Remove harness plug at the control switch. Turn the ignition switch to **On. Do not start engine.**
  - Check for voltage at harness plug pin 1 (Figure 64).
  - If voltage reading is 0, replace the control switch.

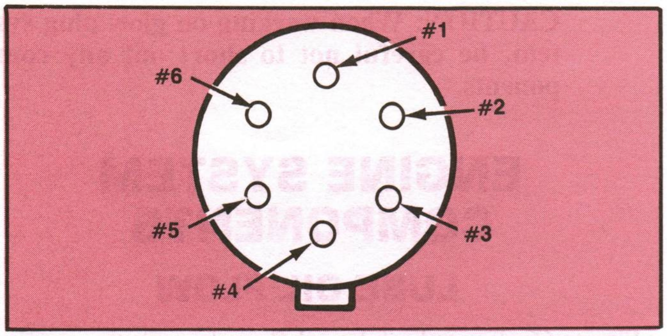


Figure 64 — Control Switch Harness Plug Sockets #4 and 5

NOTE: Replace control switch because all other checks have been made.

The problem should be corrected. Recheck for proper operation.

- If voltage is greater than 0 volts, separate engine glow plug harness to chassis harness connector. With ignition switch **On, do not start engine.** Check for voltage on chassis side of connector at pin 1 (Figure 63).
- If no voltage is detected, replace glow plug wiring harness.

The problem should be corrected. Recheck for proper operation.

- If voltage is detected, remove harness plug from after glow relay, and retest.
- If voltage is **still** detected, repair or replace faulty vehicle wiring between after glow relay and glow plug wiring harness.
- If voltage is not detected, replace after glow relay.

The problem should be corrected. Recheck for proper operation.

- If voltage is detected, repair wiring to alternator or repair alternator.
- If voltage is not detected, the problem is solved.

Recheck system for correct operation.

This concludes troubleshooting of the glow plug system operation. The next section pertains to troubleshooting the vehicle "Wait-to-Start" lamp operation.

6. WAIT-TO-START LAMP OPERATION

Normal operation of wait lamp

- Wait lamp will not come on at all if coolant temperature at control switch probe is at or above 165°F (91°C). The wait lamp will come on when the ignition switch is in the Start position, for a check of bulb function.
- **If coolant temperature is low**
  - — Wait lamp will light when ignition switch is turned **On.**
  - — Lamp will remain lit for 4 to 10 seconds depending upon engine coolant temperature.
  - — Lamp will then remain off until ignition switch is turned **Off,** then **On** again.
- **Check wait lamp operation** — Refer to the above description of normal operation of wait lamp. If the wait lamp operation is incorrect, check glow plug system operation using test lamp, as described previously. If improper test lamp signal is observed, troubleshoot and repair glow plug system, as previously described. If glow plug system operation is OK, but wait lamp operation is faulty, proceed to one of the following three tests.

A. No Wait Lamp

- **Check light bulb** — If bulb is damaged, replace and recheck wait lamp operation. If bulb is OK, proceed to the next step.
- **Jump from harness at latching relay** — Turn the ignition switch **On.** Disconnect the harness connector from latching relay. Place the jumper wire between harness connector pin 5 (Figure 65) and ground. If lamp is not lit, repair wiring in circuit from ignition switch to wait lamp to latching relay. If lamp is lit, proceed to next step.
- **Check latching relay ground circuit** — Turn the ignition switch **On.** Disconnect the latching relay harness plug. Place the jumper wire between pins 3 and 5 (Figure 65) in latching relay harness connector. If wait lamp remains off, repair latching relay ground connection and retest. If wait lamp comes on, replace the latching relay and retest.

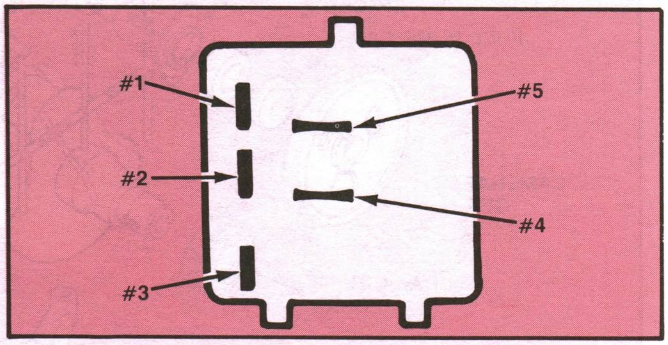


Figure 65 — Latching Relay Harness Connector

B. Wait Lamp On Whenever Ignition Switch is On

- **Check for grounded lead between wait lamp and latching relay** — Turn the ignition switch **On.** Disconnect the harness connector at latching relay. If lamp remains on, repair ground in lead between wait lamp and latching relay and retest. If lamp is off, proceed to next step.

- **Check voltage to latching relay from control switch**— Turn the ignition switch **On.** Disconnect harness connector at latching relay. With a voltmeter, check voltage between connector pin 2 (Figure 65) and ground. If reading is 11 volts or more, proceed to the next step. If reading is less than 11 volts, turn ignition switch **Off.** Disconnect harness plug at control switch. Check the continuity between latching relay connector plug pin 2 and control switch plug pin 2 (Figure 64). If resistance reading is less than 1 ohm, replace the control switch and retest. If resistance is 1 ohm or higher, repair or replace wiring as necessary. Recheck the system for proper operation.

- **Check continuity to ground at latching relay harness socket** — Turn the ignition switch **Off.** Disconnect the connector at latching relay. Check resistance between pin 1 (Figure 65) and ground. If resistance is 5 ohms or less, replace latching relay and recheck for proper operation. If resistance is greater than 5 ohms, repair or replace wiring between latching relay and power relay.

CAUTION: When working on glow plug system, be careful not to short out any components.

ENGINE SYSTEM COMPONENTS

LUBE OIL FLOW

Figure 66 shows the lube oil flow through the engine. The lubrication system of the 6.9L diesel engine is similar to that of a gasoline engine. Any major differences will be discussed in this section.

OIL PUMP AND OIL PICK-UP TUBE

The oil pump is a positive displacement gear type mounted directly to the crankcase. It drives off of the crankshaft gear as can be seen in Figure 67.

The oil pump is available for service only as an assembly with drive gear.

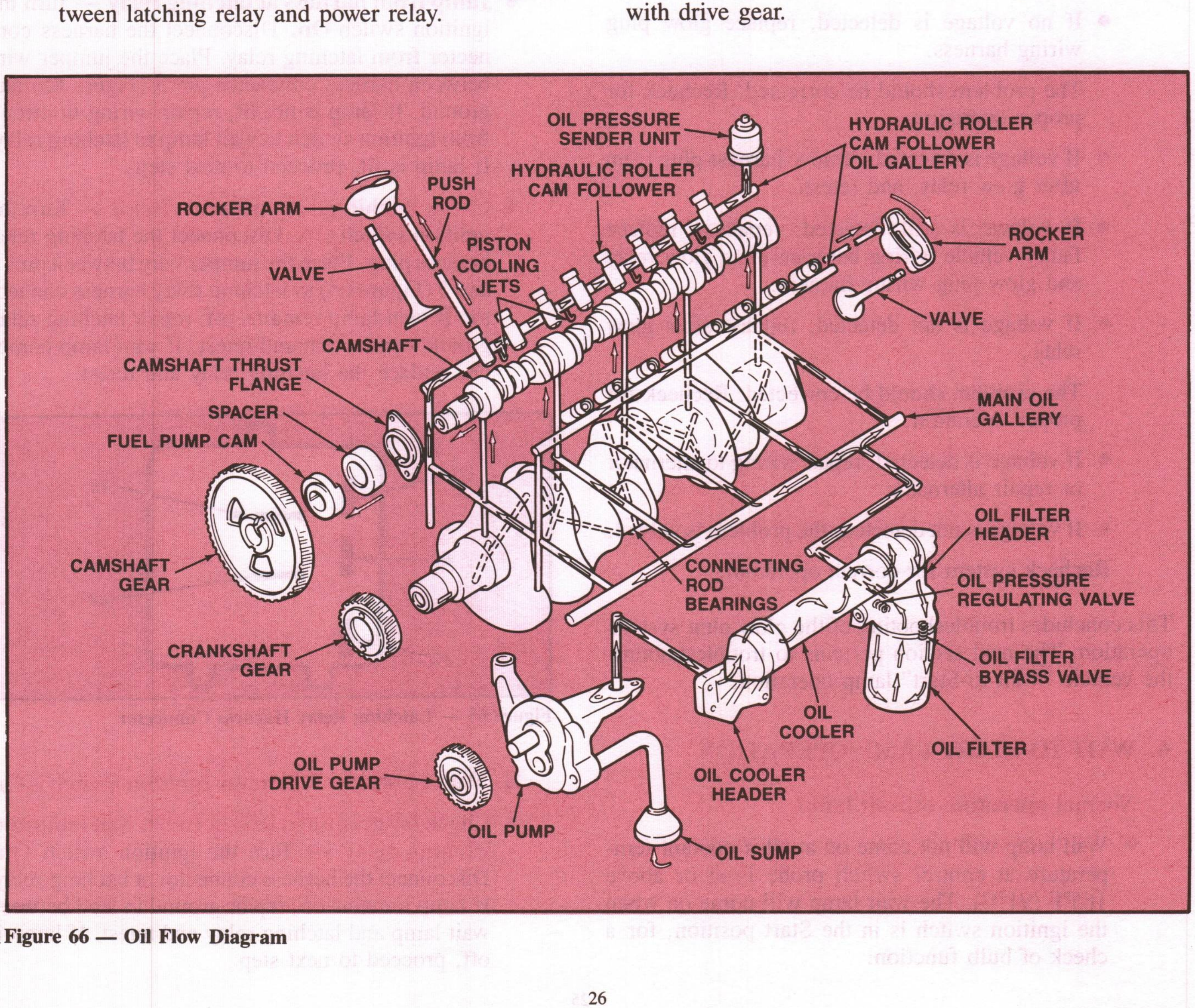


Figure 66 — Oil Flow Diagram

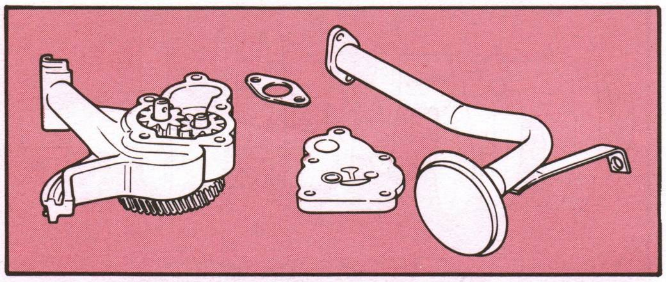


Figure 67 — Oil Pump Gears and Pick-up Tube

OIL FILTER HEADER, OIL COOLER AND ADAPTORS

Figure 68 shows the oil filter header and adaptor, rotated so that where oil and coolant enter and exit is visible. On assembly, the cooler must be pressed into the oil filter header and end adaptor. There are two O-rings at each end of the cooler which is open at each end (Figure 69). Lube oil enters from the crankcase, passes back and forth a number of times across the tubes by means of baffles within the cooler, and then enters the oil filter header. Coolant flows through the tubes and lube oil passes over the tubes. Note the oil filter bypass valve and spring and the pressure regulator valve and spring.

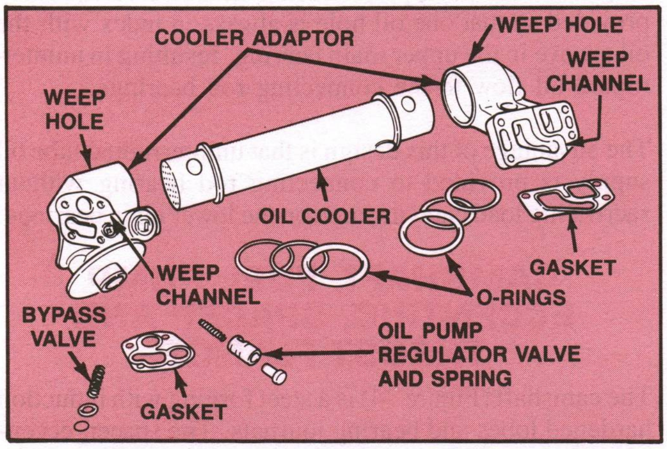


Figure 68 — Oil Filter Header, Cooler and Adaptors — E-Series Shown

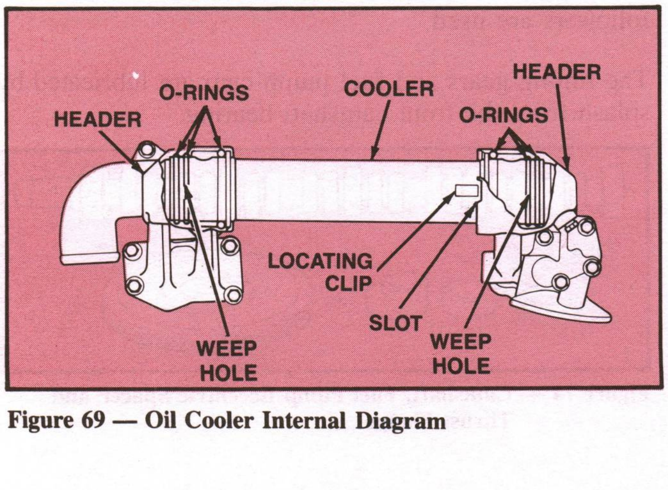


Figure 69 — Oil Cooler Internal Diagram

E-Series adaptors are shown. F-Series adaptors are similar but extend out farther from the engine.

A "weep" channel is cut between the lube oil and coolant passages in the cooler adaptors, at the point where the adaptors mount to the cylinder block. This reduces the possibility of coolant and lube oil mixing due to gasket failure. If oil or coolant is noticed leaking out of the "weep" channels, the oil cooler adaptor gaskets must be replaced. These adaptors also provide tell-tale indication of leakage through "weep" holes leading to the exterior of the headers. If at any time oil and/or coolant is observed flowing out of the "weep" holes, the oil cooler assembly O-rings are damaged and must be replaced.

COOLING SYSTEM FLOW

Since the 6.9L diesel engine cooling system flow is similar to that of a gasoline engine, refer to Figure 70 for the cooling system flow.

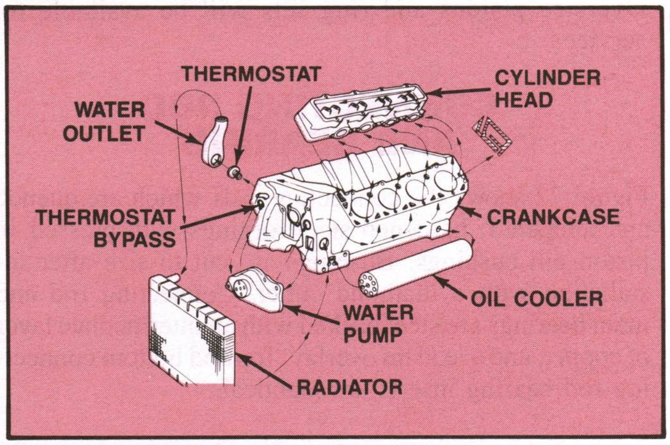


Figure 70 — Coolant System Flow Diagram

PISTON AND PISTON PIN

Figure 71 shows the piston used in the 6.9L which is made of an aluminum alloy. It has an elliptical cam profile along the entire skirt. This means that when the piston is at less than normal operating temperature, the diameter of the piston is smaller than at normal operating temperature. The diameter of the piston skirt is smaller close to the pin bore than it is across the center of the skirts (90° from the pin bore). The piston is constructed so that when it warms up and expands, the expansion will take place parallel to the piston pin (which was the smallest diameter of the skirt), and the piston will then become round. The skirt is also tapered to be a slightly larger diameter at the bottom of the skirt than at the top. The piston features a niresist insert in the top ring groove to reduce wear. This insert is made of a nickel iron alloy with expansion characteristics closely matched to those of the piston material.

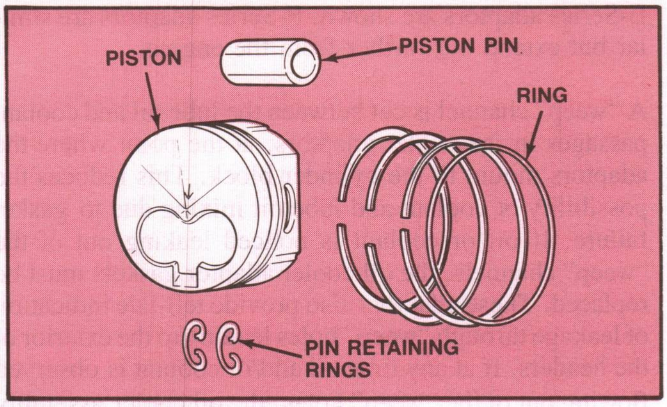


Figure 71 — Piston and Piston Pin

Piston pins are free floating design held in by lock rings on each end. The top ring is a barrel faced chrome ring made of ductile iron, and rectangular in cross section. The second ring is a grey iron tapered face compression ring. The oil ring is a double rail configuration ductile iron chrome faced ring with an internal expander spring. Oversize pistons and ring sets will be available for service.

CONNECTING ROD AND BEARING

Figure 72 shows the connecting rods which are quench and tempered, hardened steel forgings with pressed in piston pin bushings. Bushings are cut to size after installation with a diamond cutter. Connecting rod and main bearings are steel backed with an intermediate layer of copper, and a lead tin overlay. Top and bottom connecting rod bearing inserts are identical.

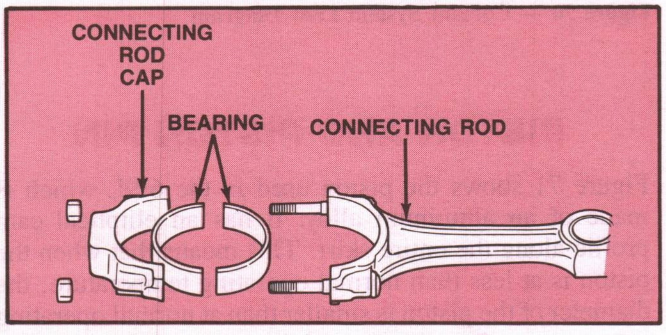


Figure 72 — Connecting Rod and Bearing

CRANKSHAFT AND BEARINGS

The crankshaft shown in Figure 73 is a steel forging with induction hardened main journals and induction hardened pin journals and fillets.

Undersize connecting rod and main bearings will be available for service in increments of .010″, .020″, and .030″.

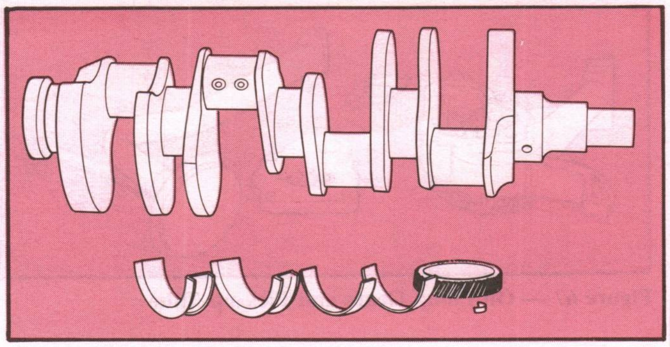


Figure 73 — Crankshaft and Bearings

The crankshaft is balanced by removing material from counterweights as necessary. Main journals are 3-1/8″ diameter and pin journals are 2-1/2″ diameter. Main and connecting rod bearings are steel backed with an intermediate layer of copper, and a lead tin overlay. All upper main bearing inserts have an oil groove. The bottom inserts **do not.**

CAUTION: When installing the bearings, make sure that the bearings with the oil groove are installed in the upper position.

Connecting rod bearings are oiled through crankshaft cross drillings from the main journals. Each main journal has two oil holes opposite each other. Two oil holes are provided so that one oil hole is always in index with the oil groove in the upper main bearing, resulting in uninterrupted oil flow to the connecting rod bearings.

The advantage of this design is that uninterrupted lube oil supply is provided to connecting rod bearing without sacrificing load carrying area on the lower main bearings.

CAMSHAFT, FUEL PUMP ECCENTRIC, SPACER AND THRUST FLANGE

The camshaft (Figure 74) is a steel forging with induction hardened lobes and bearing journals. The spacer, eccentric and gear are pressed onto the camshaft. There is also a retaining bolt which is **not** shown in Figure 74. Notice the difference in the cam profile because roller cam followers are used.

The timing gears and fuel pump cam are lubricated by splash from the front camshaft bearing.

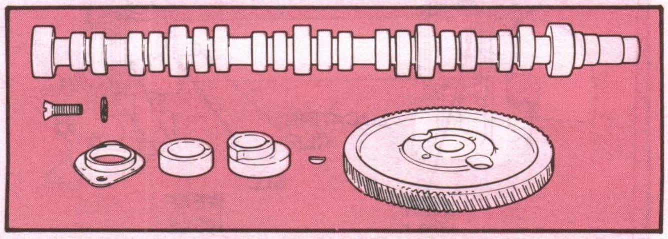


Figure 74 — Camshaft, Fuel Pump Eccentric Spacer and Thrust Flange

VALVE TRAIN

The valve train components (Figure 75) include:

- Valves
- Spring valve rotator
- Valve spring and dampers
- Umbrella oil seal used on intake valve only
- Nylon oil seals used on both intake and exhaust valve retainers
- Valve retainers
- Valve keepers
- Rocker arm post
- Rocker arm
- Push rod
- Roller cam follower

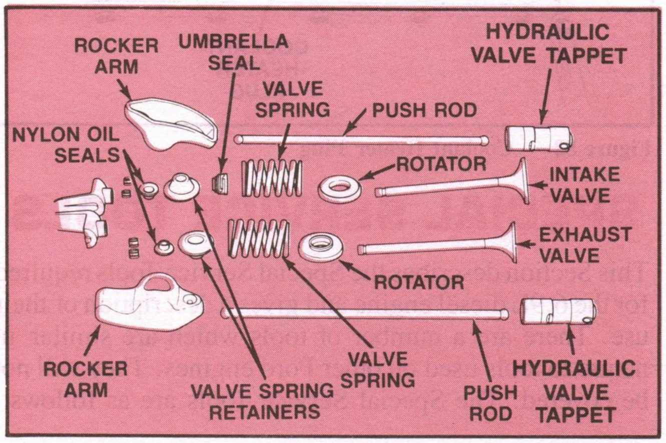


Figure 75 — Valve Train Components

Hydraulic roller cam followers (Figures 76 and 77), are used. The push rod is hollow and carries lube oil to the rocker arm assembly. The ball end which rides in the roller follower is made of carburized carbon steel, while the other ball, which rides in the rocker arm is made of tool steel. Tool steel provides better wear characteristics with the rocker arm socket. The ball end which rides in the rocker arm is coated with a conversion copper coating for identification. The rocker arm is 1.6 to 1 ratio and is a nitride-hardened steel stamping.

Valves are made of a nickel steel alloy. In addition to the nylon stem seals on the valve spring retainers, an umbrella seal is used on the intake valve. The seal fits down over the top of the valve guide, allowing just enough oil by it to lubricate the valve stem and guide.

CAUTION: When installing the push rods, make sure to place the copper colored end (tool steel) into the rocker arm. Failure to do so could cause premature wear of the push rod. If re-installing a used push rod, the copper color should be noticeable on the underside of the ball.

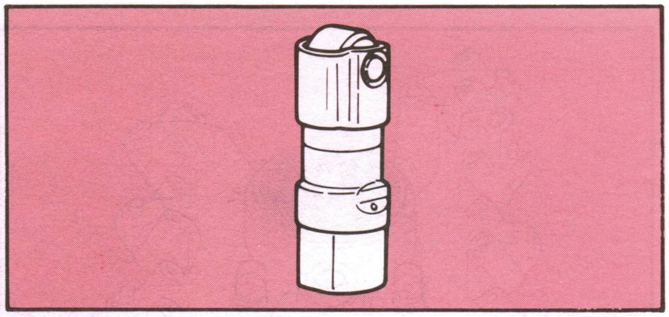


Figure 76 — Hydraulic Roller Cam

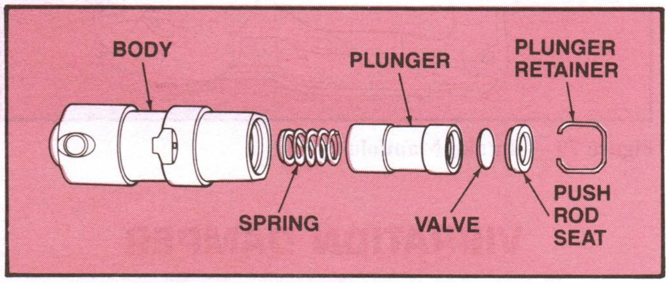


Figure 77 — Hydraulic Roller Cam Internal View

GEAR TRAIN

Timing marks are present between the fuel pump gear and camshaft, as well as between the crankshaft gear and camshaft gear. Note that while the crankshaft to camshaft marks are dots, the camshaft to fuel pump gear marks are Y-shaped to avoid confusion (Figure 78). Gear train gears are quench and tempered forgings.

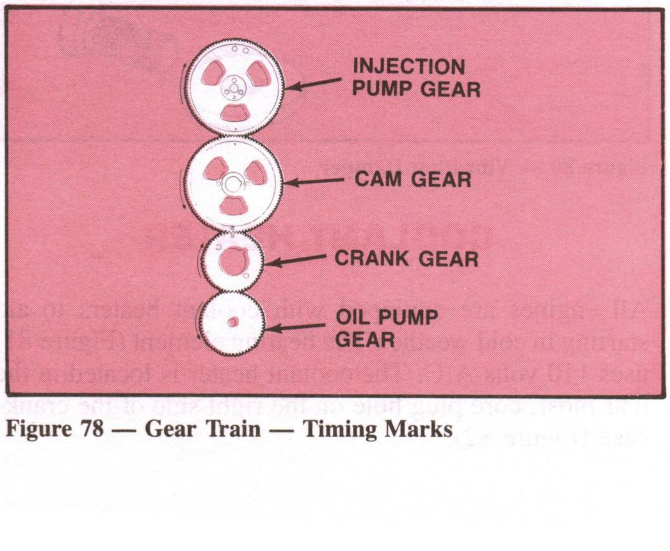


Figure 78 — Gear Train — Timing Marks

INTAKE MANIFOLD

The intake manifold (Figure 79), is one piece aluminum. The configuration of the intake manifold allows for the injection pump to be mounted in front of the manifold, rather than under the manifold. This allows for easier maintenance of the injection pump.

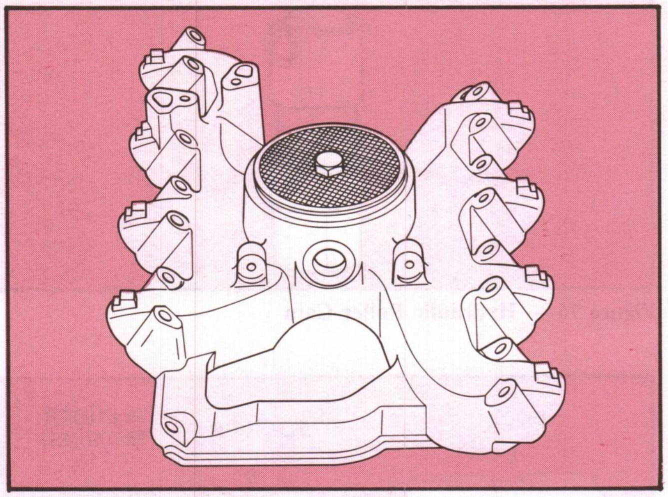


Figure 79 — Intake Manifold

VIBRATION DAMPER

A rubber bonded vibration damper (Figure 80), is used. It is comprised of an inner member, a flexible member and an outer member.

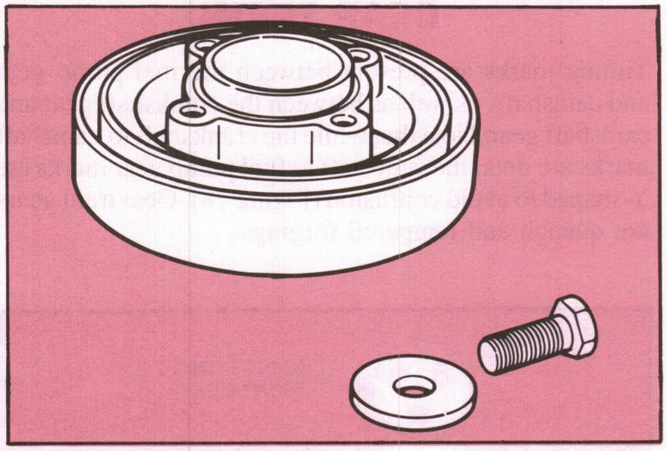


Figure 80 — Vibration Damper

COOLANT HEATER

All engines are equipped with coolant heaters to aid starting in cold weather. The heating element (Figure 81) uses 110 volts A.C. The coolant heater is located in the rear most, core plug hole on the right side of the crankcase (Figure 82).

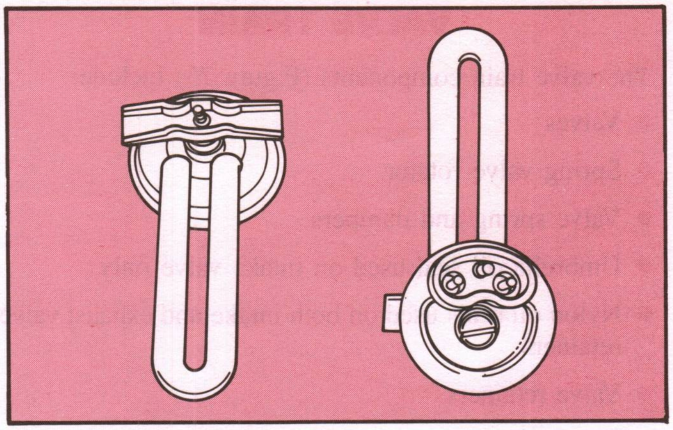


Figure 81 — Coolant Heater Element

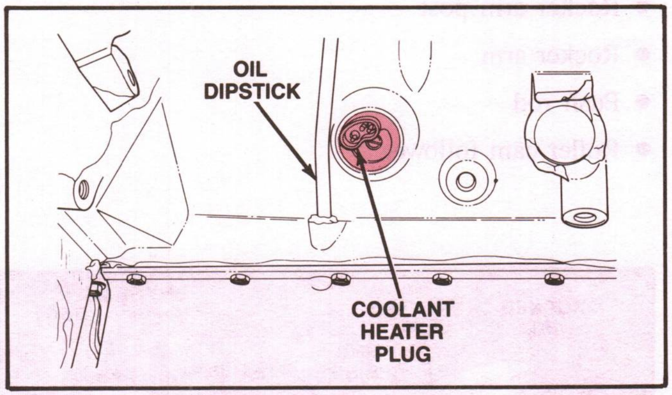


Figure 82 — Coolant Heater Plug

SPECIAL SERVICE TOOLS

This Section describes the Special Service Tools required for the 6.9L diesel engine and gives a description of their use. There are a number of tools which are similar in nature to tools used on other Ford engines. They will not be covered. The Special Service Tools are as follows:

- **Fuel Transfer Pump Pressure Adaptor — T83T-9000-A (Figure 83)** — Temporarily install this special tool with locating plate into the transfer pump, pressure port. The service technician can quickly record fuel pressure reading while the engine is operating. This tool must be used with a pressure gauge.

  The procedures for the use of this tool are described in the Fuel System Diagnosis under the Engine Performance Chart.

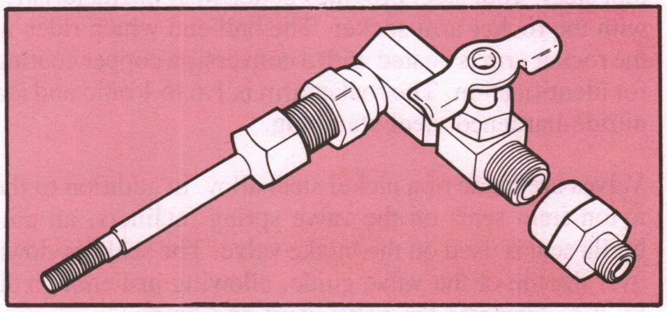


Figure 83 — Fuel Transfer Pump Pressure Adaptor

- **Injection Pump Rotating Tool — T83T-9000-C (Figure 84)** — This service tool is required for timing the 6.9L diesel engine.

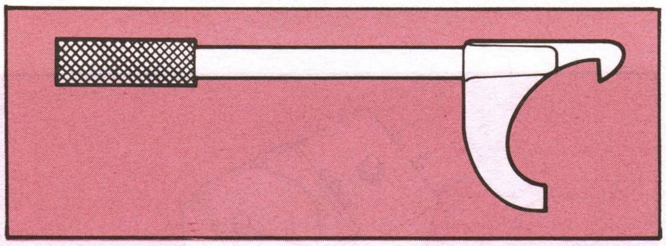


Figure 84 — Injection Pump Rotating Tool

Break torque on the three bolts retaining the injection pump to the front housing and hook the adjusting tool to the pump. By turning the pump counterclockwise (from front of engine), the timing will be advanced. Clockwise will retard the timing. After the timing has been set, the three bolts **must be** tightened to specification.

- **Fuel Line Nut Wrench — T83T-9396-A (Figure 86)** — Limited access to the fuel injector pump assembly requires the use of the Fuel Line Nut Wrench. Use with a torque wrench to tighten the fuel lines to the final torque specifications.

Procedures for removing lines from injection pump are as follows:

1. Remove injection nozzle lines, one at a time, from the injection pump using Tool No. T83T-9396-A.

   NOTE: Fuel lines must be removed following this sequence: 5-6-4-8-3-1-7-2. Install caps on each end of each fuel line and pump fitting as it is removed and identify each fuel line accordingly (Figure 85).

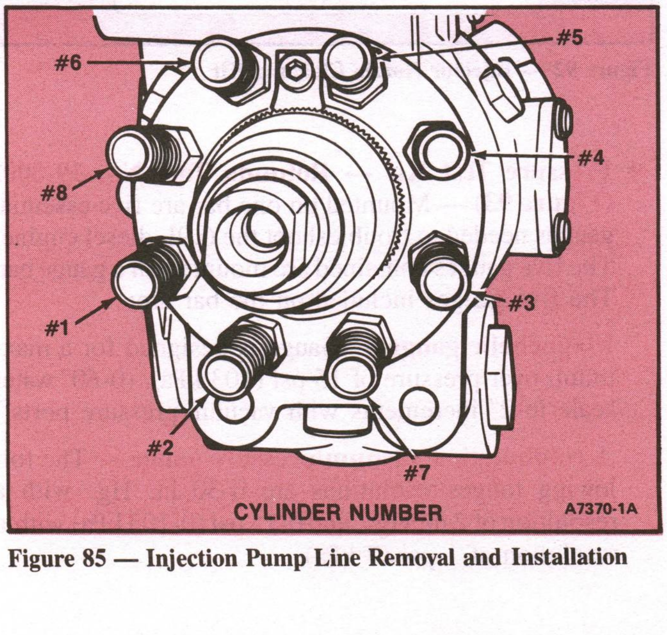


Figure 85 — Injection Pump Line Removal and Installation

2. Install fuel lines on injection pump, using Tool No. T83T-9396-A, one at a time, and tighten to specification.

   NOTE: Fuel lines must be installed in the following sequence: 2-7-1-3-8-4-6-5 (Figure 85).

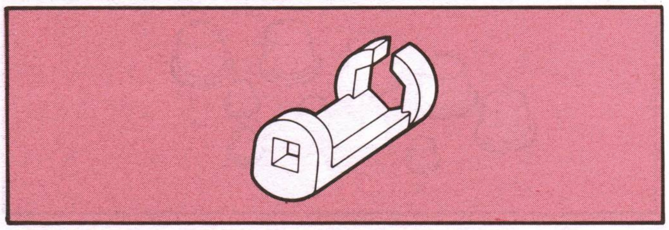


Figure 86 — Fuel Line Nut Wrench

- **Nozzle Seat Cleaner — T83T-9527-A (Figure 87)** — Nozzle assemblies must seat firmly to the cylinder head. Small deposits of carbon that may accumulate on the seating surfaces can destroy the tight seal. Before nozzle installation, the seat must be cleaned without nicking or scratching it. The Nozzle Seat Cleaner accomplishes the job easily without damage to the seat.

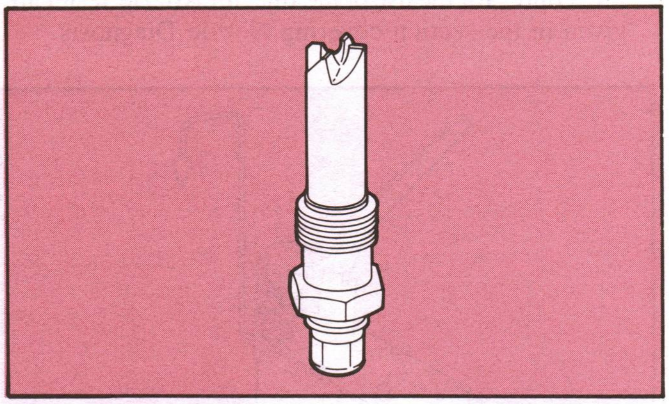


Figure 87 — Nozzle Seat Cleaner

- **Intake Manifold Cover — T83T-9424-A (Figure 88)** — This plastic cap is needed to prevent dirt or foreign materials from accidentally falling into the engine whenever the air cleaner is removed. With the air cleaner off, this plastic cap must be placed in position.

NOTE: Remove the plastic cap for compression test.

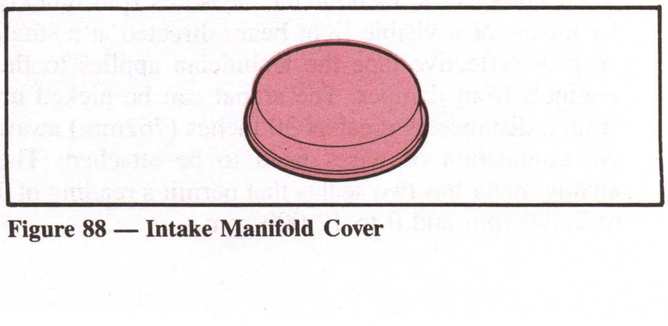


Figure 88 — Intake Manifold Cover

- **Fuel System Protector Cap Set — T83T-9395-A (Figure 89)** — These plastic sealing caps are needed to keep moisture, dust and dirt out of the engine's fuel system. Anytime the nozzles or fuel lines are separated and opened, they **must** be capped. Different sizes are included to handle all requirements.

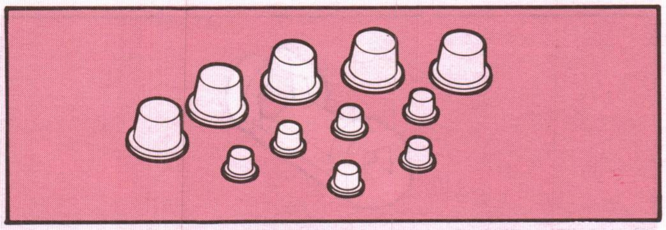


Figure 89 — Fuel System Protector Cap Set

- **Injector Nozzle Tester — Rotunda Tool No. 14-0300 (Figure 90)** — The Injector Nozzle Tester quickly tests nozzle opening pressure, leakdown rate, spray pattern and chatter. Injectors should be checked for all of these operating conditions before they are reinstalled or prior to installation of new assemblies.

  The pressure gauge is calibrated in psi/kPa and reads from 0 to 5,000 psi (0-34,475 kPa).

  Procedures for the use of the Injector Nozzle Tester are given in the section covering Nozzle Diagnosis.

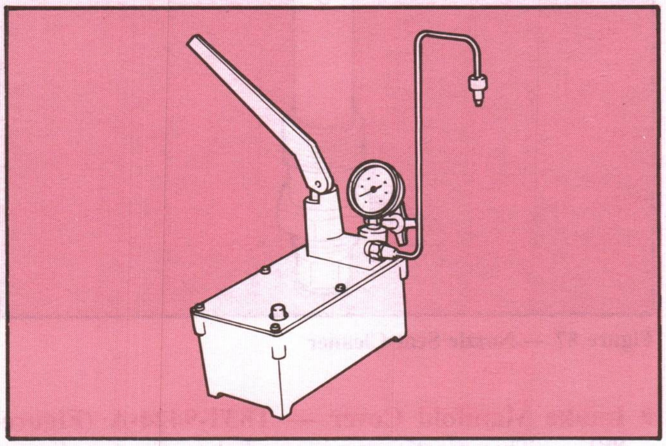


Figure 90 — Injector Nozzle Tester

- **Photoelectric Tachometer — Rotunda Tool No. 99-0001 (Figure 91)** — Since there is no ignition system, a different method **must be** used to check the rotational speed of the crankshaft.

  The photoelectric tachometer measures rpm quickly by means of a visible light beam directed at a small strip of reflective tape the technician applies to the engine's front damper. The signal can be picked up from a distance as great as 30 inches (762mm) away. No connection or wires need to be attached. The analog meter has two scales that permit a reading of 0 to 2,400 rpm and 0 to 12,000 rpm. A simple switch on the unit housing selects the meter range required. The photoelectric tachometer uses transistorized circuitry for true accuracy.

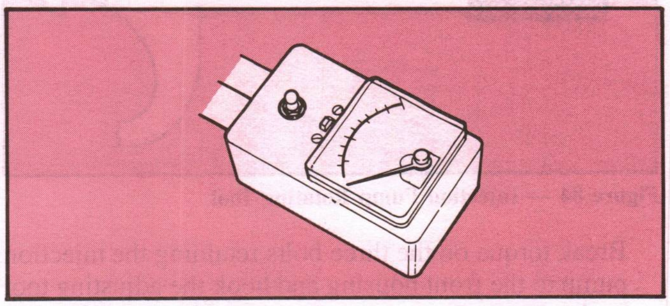


Figure 91 — Photoelectric Tachometer

- **Injector Nozzle Cleaning Kit — Rotunda Tool No. 14-0301 (Figure 92)** — This kit (containing a complete range of specially formed tools) is used to clean carbon and other foreign material deposits from the nozzle assembly.

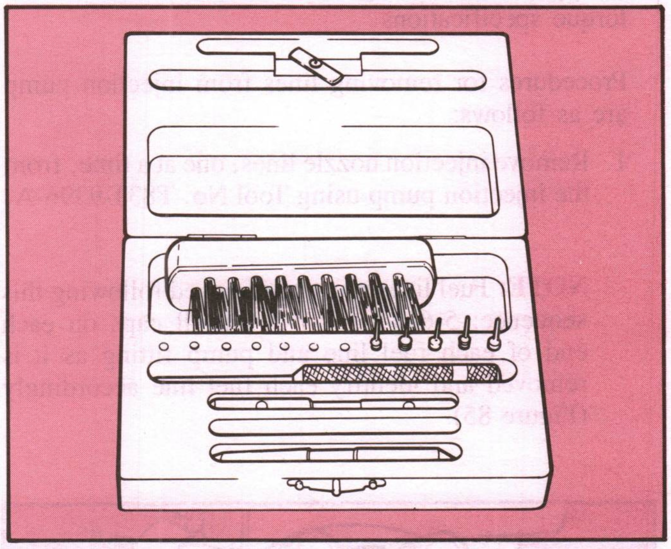


Figure 92 — Injector Nozzle Cleaning Kit

- **Pressure Test Kit — Rotunda Tool No. 19-0002 (Figure 93)** — Mounted on one bar are five essential gauges needed to troubleshoot the 6.9L diesel engine. The five gauges contained are mounted on a gauge bar. The five gauges included on the bar are:

  Magnehelic gauge — Gauge is designed for a maximum over pressure of 15 psi (103 kPa). (0-60″ water scale in 2″ increments with vacuum/pressure ports.)

  A combination vacuum/pressure gauge — The following ranges/resolutions are 0-30 in. Hg. with a resolution of 2 in. Hg., and 0-15 psi (0-103 kPa) with a resolution of 1 psi (7 kPa).

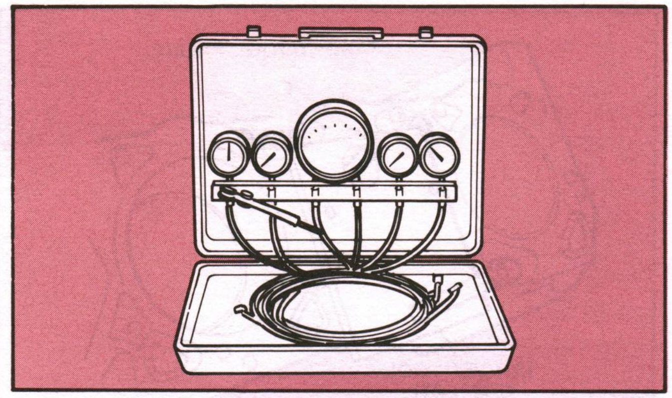


Figure 93 — Pressure Test Kit

Three pressure gauges with the following range/resolutions — 0-15 psi (0-103 kPa) with a resolution of 1 psi (7 kPa), 0-30 psi (0-207 kPa) with a resolution of 1 psi (7 kPa), and 0-160 psi (0-103 kPa) with a resolution of 5 psi (34 kPa).

Vacuum lines for the pressure/vacuum tests with fittings are included, which allow for a quick and easy hookup. A hand pump is also included which can supply pressure up to 30 psi (206 kPa) for the pressure tests.

- **Dynamic Timing Meter — Rotunda Tool No. 78-0100 (Figure 94)** — Timing of the 6.9L diesel engine is an extremely critical service operation and any adjustment must be performed with extreme accuracy. To do this properly, two signals are needed: one, the moment combustion occurs and two, piston position when combustion begins. This is accomplished through use of a luminosity probe and magnetic pick-up. The unit includes two digital displays: one for degrees of timing and the other for engine speed. An offset control allows for variable offset angles. This unit is powered by the vehicle battery.

  The luminosity probe is inserted into the No. 1 glow plug hole. The magnetic pick-up is inserted into a guide hole located just above the damper.

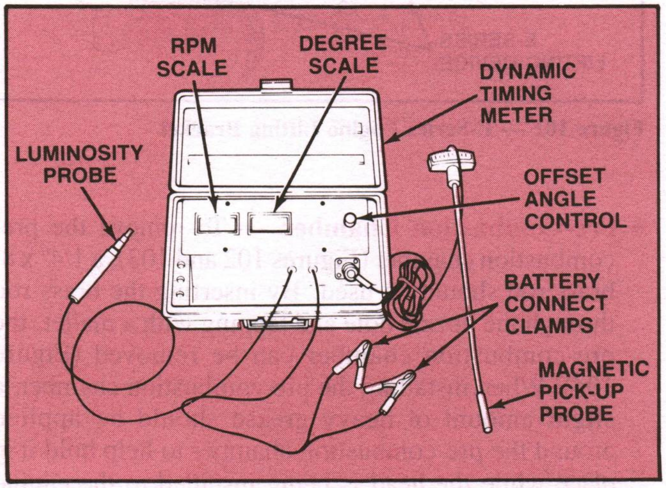


Figure 94 — Dynamic Timing Meter

- **Compression Tester — Rotunda Tool No. 19-0001 (Figure 95)** — A high pressure 0-1000 psi (0-6,900 kPa) gauge is required to test the compression of the 6.9L diesel engine. The tester threads into the glow plug holes.

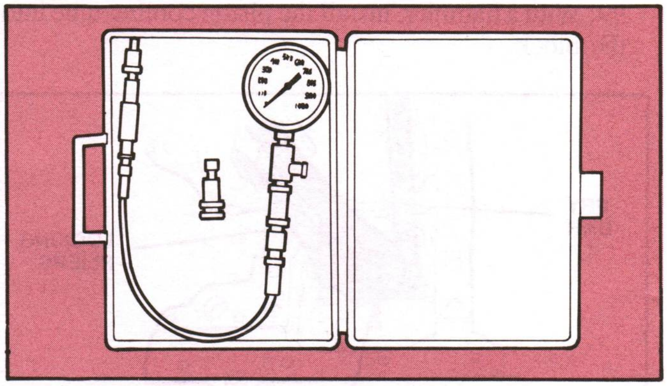


Figure 95 — Compression Tester

- **Throttle Control — Rotunda Tool No. 14-0302 (Figure 96)** — Many tests involving the 6.9L diesel engine require that the idle speed be maintained at a certain rpm. This throttle control device easily connects to the throttle linkage by turning the small adjustment knob. The rpm can be set to a constant value as called for in the service procedure.

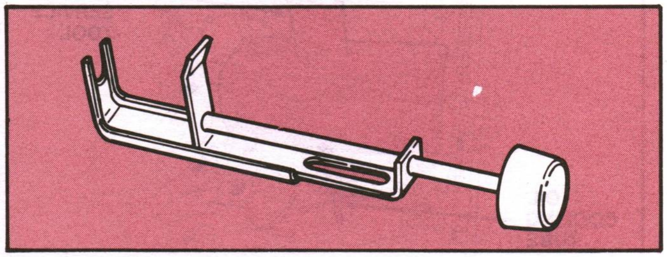


Figure 96 — Throttle Control

- **Piston Cooling Tube Installer Rotunda No. 14-0307 Tool No. D83T-6134-A (Figure 97)** — This tool is used to insert the piston cooling tube into the engine block, giving it the correct alignment. (Engine removed from vehicle.)

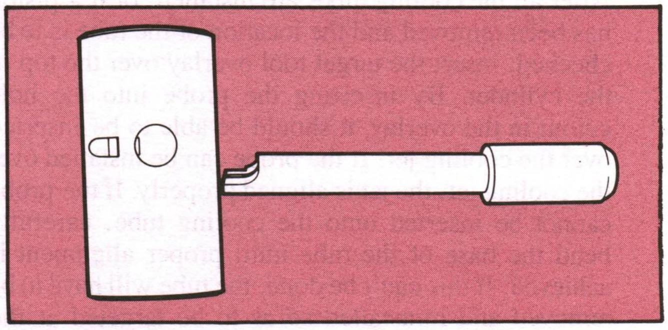


Figure 97 — Piston Cooling Tube Installer Tool

To remove the piston cooling tube, connect a set of vise grips to the cooling tube. Using a pry bar, pry up on the **vise grips only** (Figure 98). To install, insert the cooling tube into the end of the service tool. Position the service tool to the engine block as shown in Figure 99. With a hammer, install the piston cooling tube into the block.

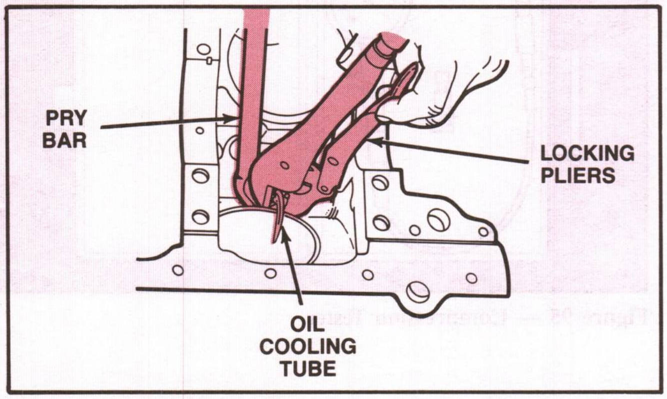


Figure 98 — Cooling Tube Removal

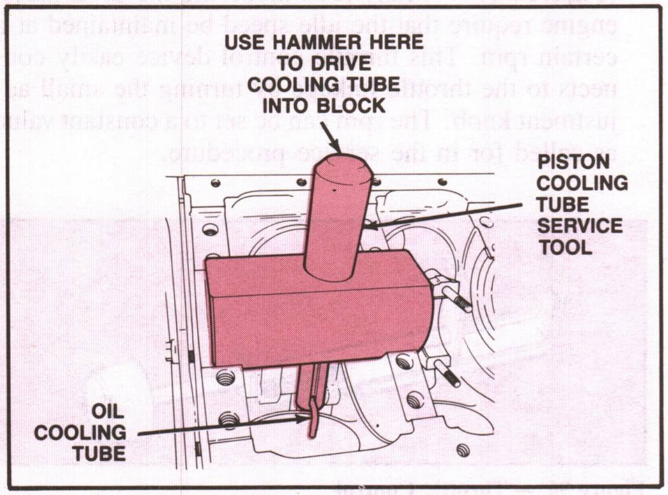

USE HAMMER HERE TO DRIVE COOLING TUBE INTO BLOCK
PISTON COOLING TUBE SERVICE TOOL
OIL COOLING TUBE

Figure 99 — Cooling Tube Installation

- **Piston Cooling Tube Target Tool — Rotunda No. 14-0311, Tool No. D83T-6134-B (Figure 100)** — This tool is used to target the piston tube to be certain that the spray will be correctly aimed at the bottom side of the piston. (Engine removed from vehicle.)

  After all the cooling tubes are installed, or if a piston has been removed and the location of the tube is to be checked, insert the target tool overlay over the top of the cylinder. By inserting the probe into the hole cutout in the overlay, it should be able to be inserted over the cooling jet. If the probe can be installed over the cooling jet, the jet is aligned properly. If the probe cannot be inserted onto the cooling tube, carefully bend the base of the tube until proper alignment is achieved. If this can't be done, the tube will have to be removed and reinstalled so as to be targeted at the correct position.

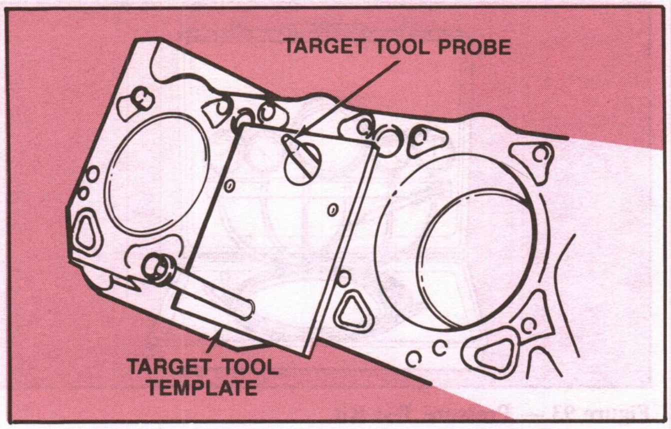


Figure 100 — Piston Cooling Tube Alignment Check

- **Connecting Rod Guide Shaft Protective Sleeves — Rotunda No. 14-0313, Tool No. D83T-6136-A** — This tool is designed to slip over the connecting rod cap bolts to protect the crankshaft journal and piston cooling tube. It is used for both removal and installation of the piston and connecting rod.
- **Engine Lifting Device — Rotunda No. 14-0312, Tool No. D83T-6000-B (Figure 101)** — This tool adapts to existing floor crane Rotunda Model No. 140071 for removal of the engine from the E-Series vehicles. This tool could also be used to remove the oil pan by lifting the front of the engine to enable removal of the oil pan, by tilting the front of the engine upwards.

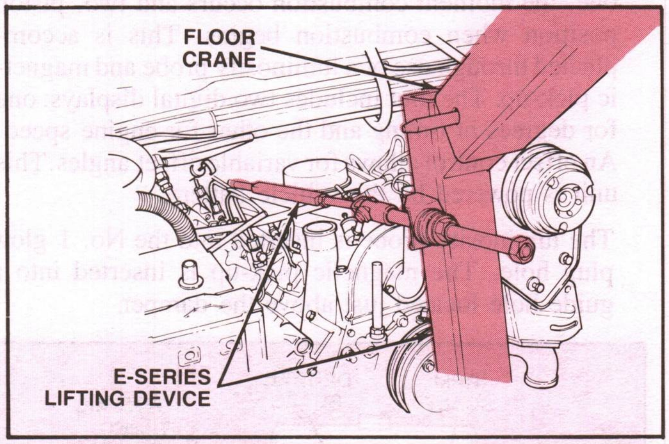


Figure 101 — E-Series Engine Lifting Bracket

- **Pre-Combustion Chamber** — To remove the pre-combustion chamber (Figures 102 and 103), a 1/4″ x 8″ brass rod should be used. By inserting the brass rod through the nozzle hole and tapping with a mallet, the pre-combustion chamber can be removed (Figure 104). When installing the pre-combustion chamber, a slight amount of heavy grease should be applied around the pre-combustion chamber to help hold it in place while the head is being installed to the engine block.

NOTE: Care should be taken when removing the cylinder head to prevent the pre-combustion chambers from falling into the cylinders. Also, when installing the cylinder head, care should be taken so that the pre-combustion chambers DO NOT fall out into the cylinders.

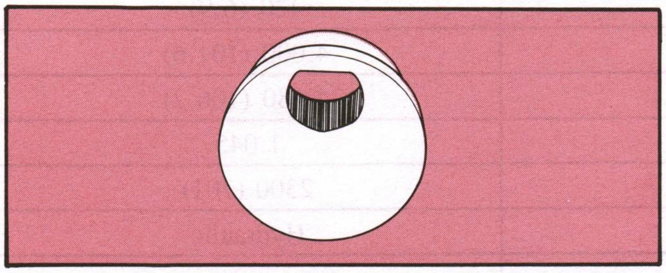


Figure 102 — Pre-Combustion Chamber — Top View

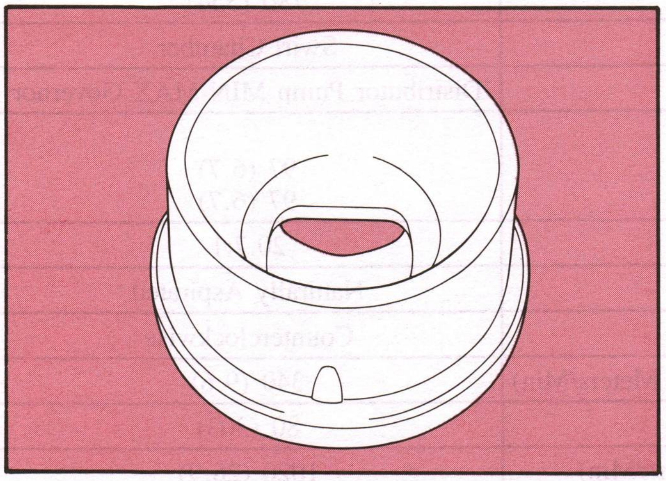


Figure 103 — Pre-Combustion Chamber — Bottom View

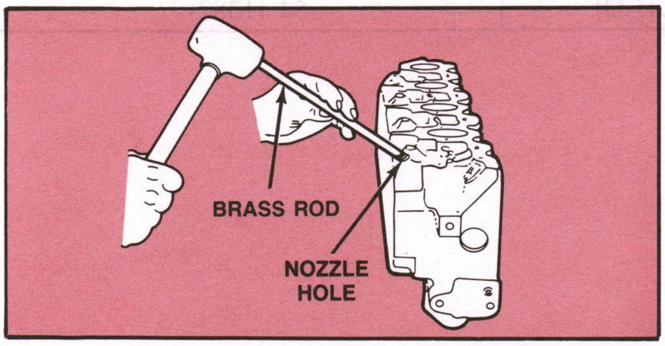


Figure 104 — Installation — Removal Pre-Combustion Chamber

ENGINE DISASSEMBLY AND ASSEMBLY

The disassembly and assembly of the 6.9L diesel engine is similar to that of a gasoline engine. There are a few precautions that should be exercised:

- **Care should be taken so that the injection lines do not become kinked or bent.**
- **When assembling the engine, care should be taken not to damage or move the piston cooling jets while the pistons are being installed into the block.**
- **Follow all tightening procedures and specifications for bolt torque.**

For detailed disassembly and assembly procedures for the 6.9L diesel engine, refer to Section 22-08 of the Light Truck Engine Service Manual.

SPECIFICATIONS

Maximum Power Gross @ 3300 RPM	170
Peak Torque Gross @ 2000 RPM ft/lbs (N•m)	310 (420)
Configuration	"V"
Cubic Displacement Inches (liters)	420 (6.9)
Bore Inches (mm)	4.000 (101.6)
Stroke Inches (mm)	4.180 (106.2)
Stroke Bore Ratio	1.045
Piston Speed at Rated Speed ft/Min (mm/Min)	2300 (701)
Valve Adjustment	Hydraulic
Engine Weight lbs (kg) (Dry — without flywheel, flywheel housing, fuel filter, alternator and starter motor)	780 (354)
Combustion System	Swirl Chamber
Injection System	Distributor Pump MIN-MAX Governor
Brake Mean Effective Pressure (BMEP) @ 3300 RPM PSI (BAR) @ 2000 RPM PSI (BAR)	 97 (6.7) 97 (6.7)
Compression Ratio	20.7:1
Method of Aspiration	Naturally Aspirated
Engine Rotation (Flywheel End)	Counterclockwise
Induction Air Flow @ 3300 RPM Cubic ft/Min (Cubic Meters/Min)	340 (9.6)
Water Flow 1 Min @ 3300 RPM Gal/Min (liter/Min)	80 (303)
Exhaust Flow @ 3300 RPM Cubic ft/Min (Cubic Meters/Min)	1020 (28.9)
Intake System — Maximum Restriction in./H_2O (mm/H_2O)	25 (635)
Exhaust System — Maximum Restriction in./H_2O (mm/H_2O)	54 (1382)

NOTES

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